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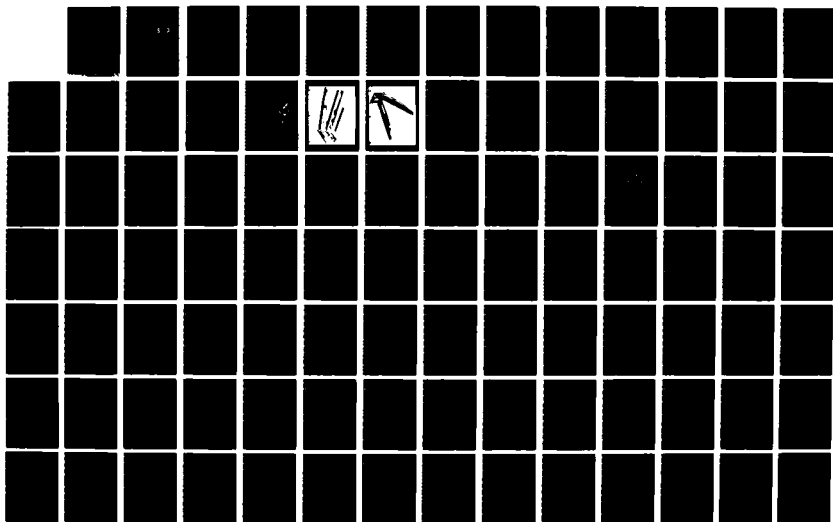
LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
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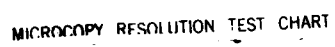
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Lightweight Towed Howitzer Demonstrator

Final Report

Volume A

Overview

April 1987

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AD-A183 982

Contract Number DAAA21-86-C-0047

FMC CORPORATION
Northern Ordnance Division
4800 East River Road
Minneapolis, Minnesota 55421

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The LTHD (Lightweight Towed Howitzer Demonstrator) was to be a 9,000 lb equivalent to the M198, transportable via Blackhawk helicopter, with reduced emplacement time using fewer personnel. The FMC design achieved weight reduction via a mortar-like configuration, composites structure, and hydraulic actuators. Recovery of power from the recoil system, in turn, facilitated crew reduction via hydraulic emplacement, four-way joystick tube lay, and power ramming. FMC completed Concept Development (Ph I) and two-thirds of Detailed Design (Ph II) prior to funds running out.		

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C/140	Firing Stability
C/150	Lanyard Actuator
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C/230	Towing Stability
C/240	Traverse Actuator
C/250	Tube Interface
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C/270	Walking Beam Actuators

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Abbreviations

ARDEC	Armament, Research, Development and Engineering Center
CAD	computer-aided design
CEL	EMC Central Engineering Laboratories
CG	center of gravity
DOF	degree-of-freedom
DTIC	Defense Technical Information Center
FEA	Finite Element Analysis
GFE	Government-Furnished Equipment
HF	human factors
HMMWV	High-Mobility Multipurpose Wheeled Vehicle
LAPES	Low Altitude Parachute Extraction System
LTHD	Lightweight Towed Howitzer Demonstrator
NBC	nuclear-biological-chemical
QE	quadrant elevation
TDP	Technical Data Package

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 & Accumulators
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The author apologizes if any names were inadvertently left out.

FMC LTHD

SummaryIntroduction

A Blackhawk-mobile 155mm howitzer has been identified as a potential need within the US Army. The Lightweight Towed Howitzer Demonstrator (LTHD), providing M198 performance in a 9,000 lbm package, is a step toward determining the feasibility (and perhaps tradeoffs necessary) to meet this need.

This report documents the FMC effort toward this project. It is organized into nine volumes by the basic subjects covered.

Vol	Description
---	-----
A	Overview
B	Technical Presentations
C	Dynamic Analysis
D1	Structural Analysis less Cradle and System
D2	Structural Analysis of Cradle
D3	Structural Analysis of System
E	Hydraulic Component Design by York
F	Systems Engrng Analysis, QA, Test Plans
G	Technical Data Package

Program Performance Status Summary

The following summarizes the status of the design activities at the time the program funding was discontinued.

1. It was estimated that we were 65% complete with the Phase 2 Engineering effort. This estimate was based on our latest estimate to complete data which projected that the Phase 2 activities would not finish until week ending May 17.
2. Approximately 55% of the parts have been detailed [G, Tech Data Package].
3. The major area in which we were behind schedule and risks remained was the composite cradle. As is evident by the detail which is included in the analysis section, this part is the most complex and difficult and the design was still in a state of flux. We had identified a qualified subcontractor and had defined the terms and conditions for the contract.
4. The [unofficial] engineering estimate for Ph 3 cost is \$4.5 million.

Technical Overview

The "power-to-weight ratio" necessary creates, besides the weight reduction, very significant firing and towing stability challenges. These challenges are further enhanced by the rapid emplacement/speedshift/displacement requirements.

A trade-study of 144 basic configurations [B/100pg3-13] resulted in the selection of a long recoil stroke, low trunnion, mortar-like configuration (with forward-pointing trails) for firing stability, simple (minimum weight) recoil system and load path, and its affinity to produce component shapes highly compatible with high strength-to-weight composites.

A serious problem with the mortar-like configuration came to be breech access and projectile ramming.

Due to the already present hydraulic system, it was decided to build upon this system by adding a hydraulic rammer and a recoil energy recovery system to compliment it.

Hydraulics were already employed

To minimize the weight of the equilibration-elevation-traverse subsystem (through the use of kevlar-wrapped hydraulic actuator technology developed for aircraft [by York Industries]), and

To extract the spade to achieve the displacement time requirement.

Extensive use of hydraulics, while providing design flexibility, threatened to complicate the controls and degrade reliability to an unacceptable point.

Fortunately, our teaming relationship with Marotta Scientific produced a clean system solution to the numerous potential trouble points. The controls are "user friendly", and reliability analysis suggests the LTHD will meet M198 reliability targets [F/130].

The anticipated weight savings of the mortar approach using high-low bearings (elimination of the 250 lbm turntable bearing plus heavily loaded understructure) was largely consumed by the energy recovery system addition.

The FMC LTHD, as a result of the breech access problem, broke even on what was originally felt to be a weight advantage over a more traditional configuration, and traded simplicity for energy recovery.

A second serious problem came to be our underestimation of the magnitude of complexity, interdependence (design-materials-analysis-fabrication), and resultant design and fabrication costs of composite components.

Two major structures (the gimbal and platform) were converted to metal (titanium) to shed some of this risk, leaving the cradle and trails.

Slow resolution of this problem (on the cradle and trails) not only added to the design interdependence problem, already being strained by the hydraulic subsystem, but also put the demonstration in jeopardy and delayed recognition of pending cost overruns.

These delivery and cost problems produced a situation that made it best from both the Army's and FMC's viewpoint that the effort be terminated.

Although we were unable to progress to a point of justified confidence, the mortar configuration is still felt to provide components more compatible with composites than a conventional howitzer.

A more detailed view of the project is provided by section 110 of this volume [A/110], the Design Descriptions and Considerations (in a structured format). This section, in turn, makes extensive reference to the balance of this report for more detailed information.

The following paragraphs in A/110 are of general interest:

Achievement vs Goal Summary,
Further Weight Reduction, and
Lessons Learned

Once again, this report is divided into the volumes listed below. These volumes, in general, include only the most current relevant data.

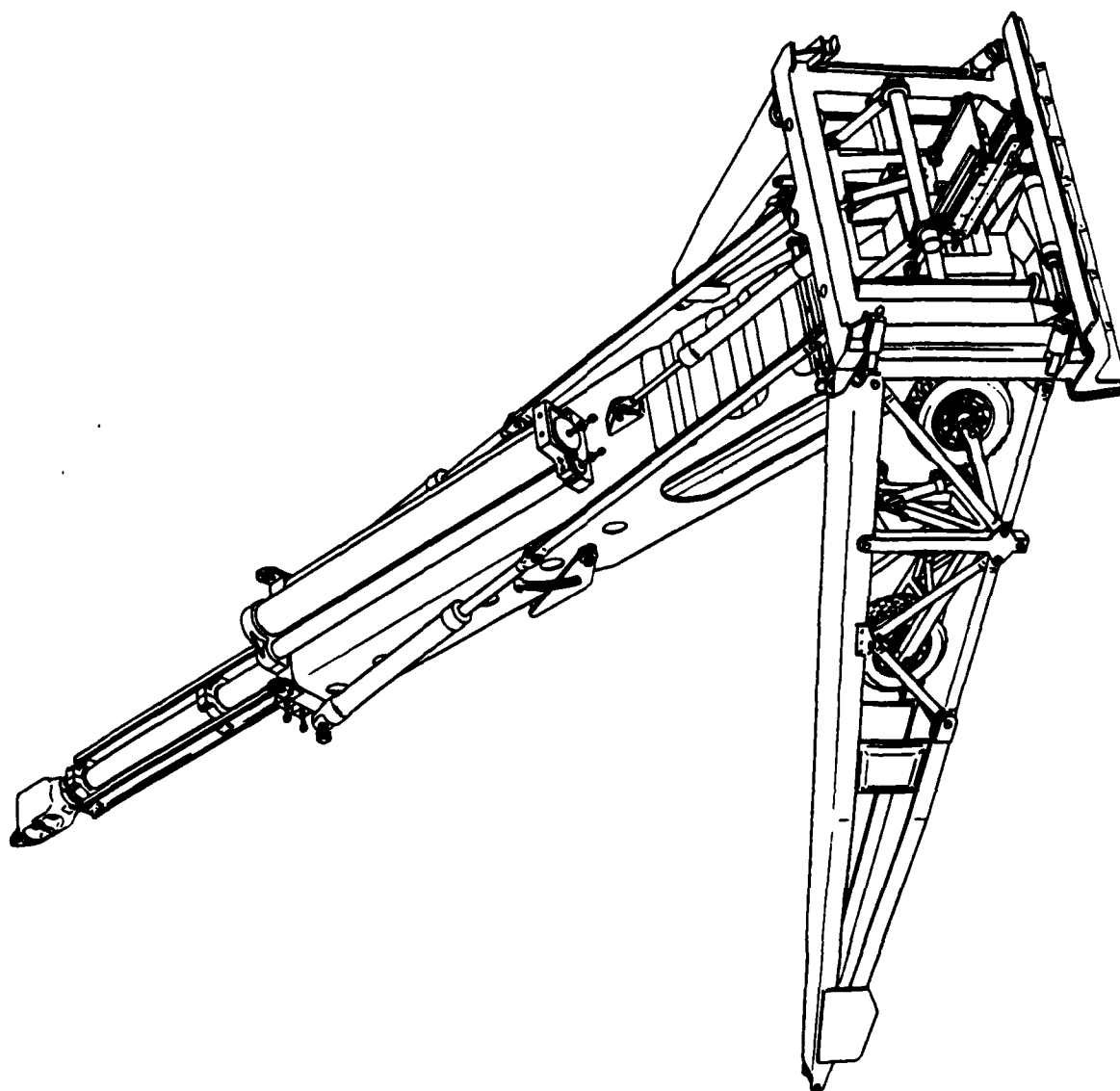
The design evolution records have not been included. The only exception to this is the cradle [D2] and the fixed orifice recoil [C/210].

When design has evolved beyond the analysis (frequently due to results of the analysis), this is noted.

Vol	Description
A	Overview
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D1	Structural Analysis less Cradle and System
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Technical questions should be directed to Bart Anderson, 612/337-3325 or 571-9201.

LIGHTWEIGHT TOWED
HOWITZER DEMONSTRATOR
PERSPECTIVE OVERVIEW
T-12505710-001 / B



N-69005
4-24-87



FIG. A/100-16 FMC LTID CARRIAGE (1/2 SCALE MODEL)

A/100-6

N-69012
4-24-87



This alphabetical list of subjects facilitates a description of the FMC LTHD design as well as the considerations involved in the decision process used to arrive at each design position.

Accumulators	Latch Position
Achievement vs Goal Summary	Lessons Learned
Actuators	Loading System
Breech	Mortar Configuration
Breech Band	Muzzle Brake
Cannon	Outer Breech Band
Cannoneer 1 Manifold	Platform
Compound Actuator Assembly	Primer Auto Loader
Cradle	Rails (see Cannon)
Elevation/Equilibration/Traverse System	Recoil System
Energy Recovery System	Spade
Fire Control	Speedshift Assembly
Firing Plate	Thermal Growth Control and Anchors
Firing Stability	Towing Stability
Further Weight Reduction	Trails
Gimbal	Valves
Heat Removal and Sustained Firing Rate	Walking Beams
Hydraulic leaks	

The following "paragraphs", one for each subject above, list the major considerations and features of the design chosen, within a hierarchical structure. Each subparagraph is preceded by a symbol to denote the relative advantage or disadvantage to the system provided by that item.

Symbol	Meaning
-----	-----
+	Advantage to system
-	Disadvantage to system
*	Neutral to system
/	Considered but not used
>	Potential weight savings

Only "considered but not used" items that are considered currently pertinent are included.

Within each paragraph are also references to other sections within this report.

References enclosed by () refer to other paragraphs within this section; for example, (see Accumulators).

References enclosed by [] refer to other sections (possibly in other volumes); for example, [B/100pg14] refers to Volume B, Section 100, page 14.

Accumulators

- + Kevlar-wrapping (except reservoir accumulator); Kevlar is a TM of DuPont
- + Reduces weight
- + Increases resistance to explosion from small arms fire
- + Basic design is already certified for flight and in use

- + Short stroke indicators
- + Provide adequate volume indication in minimum space for minimum weight
- + Basic design is already certified for flight and in use

Achievement vs Goal Summary [B/600pg12thru35, for goals]

(* indicates acceptable performance anticipated)

- Weight reduction

- Probable weight = 9,200 lbm (see Further Weight Reduction)
- * System configuration (see Mortar Configuration)
 - * Structural loading [D1/160, Load Conditions]
- * Component configuration [G/050, Index to TDP]
 - * Material selection
 - * Structural Analysis [D1,D2,D3; Structural Analysis]
 - LTHD design is weak in documented composites producibility
- * Firing stability [C/140]
- * Towing stability [C/230]
 - + Probably better than M198
- * Downrange accuracy
- * M198 envelope
 - * C130, LAPES, helicopter, 5 ton truck
- * Operational procedures [A/140]
 - * Emplacement/Speedshift/Displacement in 3 minutes with crew of 4
 - * Firing
- * M198 Performance
 - * Rate of fire
 - * Maximum
 - M198 is 4 rounds per minute, LTHD is 3.2
 - * Sustained
 - * Heat capacity of lightweight tube could be a problem
 - + Unique tube mounting provides additional heat conduction, storage, and convection (see cannon)
 - * Analysis of heat removal with free air needed, but problem probably resolvable
 - * Range
 - * AZ/QE limit
- * Cost if fielded
 - * Production
 - Hydraulic rammer and energy recovery system increase cost
 - * Quality
 - Honeycomb in cradle and trails may present QA problem
- + Human factors
 - + Lunette load, spade & firing plate installation/removal, breech operation, ramming, and elevation/traverse reduce load on cannoneers below that of M198.
- * RAM-D [F/130]
 - * Soft degradation
 - LTHD degradation may not be as soft as M198
- + Safety [B/400pg7-2] [F/120]
 - + Probability of hand-in-breech, getting-hit-by-recoil, blast-overpressure-damage, load-hitting-helicopter, and falling-under-wheels reduced relative to M198.

Actuators

- + Kevlar-wrapping (when actuator is large enough to justify)
- + Reduces weight
- + Basic design is already certified for flight

- + Locked position is unaffected by hydraulic failure
- + BearLoc (TM of York) provides normally on lock at any piston position
 - * Used on elevation and traverse system
 - * End cap/sleeve is interference-fit to rod, must pressurize to release
- + Pinlocks provide lock with hydraulic failure (used in landing gear)
 - * Used on walking beam actuators
- + Self-lubricating bearings employed extensively

Breech

- * M185 style breech
- * Standard spring pack is retained (loading is at 600 mils max)
- * Hydraulically opened and closed [C/100]
 - + Eliminates one of M198's safety hazards [B/400pg7-2]
 - * Cannoneer cannot reach breech while operating control valve
 - + Facilitates compliance with human factors requirements
 - + Lighter than titanium breech cam
 - * Pilot-operated check with manual override facilities
 - * manual opening
 - * protection from closing due to a hydraulic hose failure
 - * manual closing (by pushing manual override button)
- * Primer Auto Loader mounted on door to facilitate mechanized primer handling
 - * Cannoneer insertion of primer from side is probably not reliable method
 - + Keeps Cannoneer from having to stand directly behind breech
 - * Hydraulic interlock (see Cannon) only allows primer insertion at battery
 - * Normal load position is 3 feet out of battery

Breech Band [D1/150] [D1/190]

- * A two-piece design is used to facilitate breech removal without turning the tube.
- * The inner breech band is steel.
- * The outer breech band is aluminum. See Outer Breech Band.
- Whether or not it's necessary to keep the inner and outer breech band centerlines coincident over a broad temperature range and if so, how, has not been worked out.

Cannon

- * Cannon recoil path is guided by rails attached to sides of tube
- * AlSiC rails are attached to tube via five collars
- + Rails, by being part of recoiling mass instead of stationary mass;
 - + increase the recoiling mass
 - + increase the heat convection area (from the tube)
- complicate tube replacement
- * Collars are spaced to take spin-up torque from battery or load position
- * Titanium collar (nearest breech) serves as thermal anchor
 - * Provides strength required to accelerate rail assembly during recoil
- * Other collars are AlSiC
 - * lower strength requirement facilitates lighter material
 - * AlSiC CTE match to tube is adequate
 - * maximum heat transfer to rails
 - * collar-key geometry maintains tube to rail centerline despite CTE delta
- * Rail and collar assembly is interchangeable from tube to tube

Cannoneer 1 Manifold

- * Mounted on inside of cradle with control handles protruding thru cradle wall
- * Provides all loading controls and energy level gauge (see Loading System)
- * Control valve handles must be depressed before position can be changed

Compound Actuator Assembly

- * Most of major hydraulic components are mounted between the two "end caps", the front-cradle manifold and the midcradle manifold
- * two recoil and two counterrecoil actuators set length
 - * Cylinders made of AlSiCp
 - * thermal growth closer to steel (than aluminum)
 - * good bearing properties
 - / kevlar-wrapped steel considered by dropped due to thermal insulation
- * other end-to-end components are fixed on one end and floated on the other
- * two counterrecoil accumulators
- * load position actuator (sets and holds tube at "latch" position, see Latch Position)
- * ramming actuator (pulls load tray forward, see Loading System)
- * tube bundle to transfer fluid control signals between manifolds
- * Most "automatic" control valves are mounted within two "end caps"
- * ram control (see Loading System)
- * rail position valves "feel" flats in rail, identifying load and battery positions
- * checks, pressure control, flow control, etc.
- * All components can be removed without pulling compound actuator assembly
- * Way bearings for rails mount within "end caps"
 - + easily replaced without pulling tube
 - + provides maximum wheelbase for recoiling mass (about 102")
- * explosively bonded bronze to aluminum provides minimum weight bearing
 - + Self-lubricating fabric bearing from Torrington also looks feasible
- * Alignment of tube centerline with AZ-QE centerlines over full temperature range facilitated via compound actuator mounting to cradle (see Thermal Anchors and Thermal Growth Control).
- * Projectile spin-up torque taken from rails and reacted into cradle via mid-cradle manifold [D1/170]
- * Recoil force taken from recoil rods and reacted into cradle end via front-cradle manifold
- * Heat rejection from recoil
 - * into the oil will be transferred into large-convection-area aluminum-walled reservoir accumulator mounted on top of cradle
 - * into recoil cylinder walls will have to be removed from air space within cradle via vent holes in cradle rood (see Cradle)
 - * is somewhat insulated from counterrecoil nitrogen precharge by insulated accumulator walls
- Both the front and midcradle manifolds are expected to have trouble meeting their weight targets
 - * FEA analysis on them has just started
 - * the forged aluminum is a long lead item
 - * if strength is a major problem, titanium plate would solve that problem, but the weight problem would probably intensify

Cradle [D2]

- * Carbon fiber epoxy with nomex honeycomb core

- + should provide better dimensional stability than traditional steel cradle
- * Front edge has to be thickened to about 0.5" to handle recoil loads
- * Discontinuity at midbottom where spin-up torque is taken out is too complex
 - * should be reconfigured (although Morton Thiokol feels its ok as is)
 - * minimization of discontinuity would simplify multiple sourcing
- * Should add holes in roof forward of midcradle manifold to vent trapped hot air (primarily from barrel)
- * strains forward of midcradle manifold are very low
- * Torrington fabric bearing rings may be best method to provide galvanic insulation and transfer load into trunnion
- * Morton Thiokol is interested in making a subscale cradle under IRAD
- * Design is probably conservative
 - * Design torque is too high
- * Titanium shims, as a means to increase joint carrying capacity, failed

Elevation/Equilibration/Traverse System [C/110]

- * Elevation actuator located to maximize resolution at low QE's [B/700pg19]
 - + results in a single actuator, which minimizes weight
 - * one actuator is less likely to fail than two, but redundancy is gone
 - produced reduced resolution at very high QE's
- * Equilibration actuators are as forward as possible
 - + Improves firing stability
 - + Improves equilibration match
 - + Simplifies load path into cradle
 - + Facilitates same load path as that used to tie in trails
 - Necessitates "equilibration links" [D/120]
 - * composite strut with self-aligning bearing in each end
 - * slip joint in equilibration actuator to accommodate any "lift"
 - / original kevlar cables (tm of dupont) were abandoned because
 - pulley size and weight exceeded space and weight available
 - cable twist could rotate equilibration rod end, possibly causing interference with cradle wall
 - minor concern over cleaning chemicals from bundle of cable strands
 - / Slip ring tie-in to front-cradle manifold, proposed for durability reasons, was dropped for cost and lead time reasons
- * Equilibration system adjusted for temp with accumulator volume adjustment
 - * Uses central accumulator detached from equilibration actuators
 - * one accumulator is less likely to fail than two, but redundancy is gone
 - Accumulator location may allow gas to pick up heat from reservoir
 - + Elimination of oil reservoirs and their maintenance to avoid dry seals (as on M198)
- + Facilitates bellows accumulator and its advantages [B/400pg4-24]
 - + Would eliminate need for precharge maintenance
 - + Would provide faster gas temp stabilization after elev or depression [B/400pg5-27]
 - / Bellows accumulator not used for LTHD due to long lead time, tooling costs, and poor last-minute design-change flexibility
- + Pressure adjusted from stored energy via pressure intensifier
 - + Amount of equilibration required can be read on pressure gage
 - + Elimination of need to mechanically move pivot point
 - + Reducing time to adjust to a minimum (probably in 3 min empl time)
- + Equilibration pivot point optimized [C/110]
- + QE firing lock is BearLoc on equilibration actuator (see Actuators)
- * Equilibration is turned on after emplacement, off during displacement

- * Distance of tube from AZ/QE axis necessitated concern over aiming accuracy (see Fire Control)
- / Slip rings from Torrington and/or Shamban were considered but not used
 - + Increased fluid system stiffness
 - Increased weight
- * Analysis and experience suggested they weren't needed
- * They could be added later

Energy Recovery System

- * Tapped from counterrecoil portion of recoil system (see Recoil System)
- * Is controlled to constant pressure (3,000 psi) by a pressure regulator
- + Can be supplemented by an external hydraulic power supply
- + Energy available is displayed at cannoner 1 manifold (see Loading System)
- + May facilitate reduction in crew
- If insufficient energy is available, human effort required is slightly more than totally mechanical system
- Energy recovered from firing zone 4 and below may not be enough to cover energy requirements Equilibration Link
- * Firing a charge with no projectile may facilitate recharging energy level

Fire Control [D/130]

- * M198 fire control is mounted on secondary trunnion
 - Special direct fire scope is required to see over roll bar (see Platform) [B/700pg69-70] [F/140]
 - + damping can be added to attenuate firing shock seen by fire control
- * Secondary trunnion follows primary trunnion via a parallel linkage
 - Additional sources of error are introduced [B/600pg106] [D/130pg4]
- * Parallel linkage is carbon fiber epoxy
 - + maximum dimensional stability over temperature range
- * Linkage is adjustable
- * Fire control is high relative to cradle
 - + Panoramic telescope has 6400 mil field of view

Firing Plate (see Spade)

Firing Stability [C/140]

- * Firing stability (hop and skid) was achieved by employing the concepts in order of increasing risk and weight (lowest risk and lightest concepts applied first)
- * Lower risk lighter weight concepts employed
 - * Low trunnion
 - * Long recoil
 - * Shifting weight forward and to the right (for projectile spin-up)
 - * Hydraulic system forward
 - * Equilibration system forward
 - * Brake system in right trail
 - * Increased spade area
 - * Rod pull profile that overloads system early (and underloads later) relative to maintaining constant overturning moment [B/700pg15]
 - * Rigid trails to minimize storage of strain energy (with subsequent release during counter recoil)

- * Concepts applicable to mortar configuration not employed
 - / High beta/blast-overpressure muzzle brake (see Muzzle Brake)
 - * Viewed as beyond logical scope of LTHD
 - / Mild version of soft recoil (see Recoil System)
 - * Increase in risk not warranted
 - / Secondary recoil
 - * Added weight without facilitating any weight reduction

Further Weight Reduction (a possible strategy)

- * Correct overdesign in projectile spin-up torque
 - * Design projectile spin-up torque was 42,000 ft-lb (PIMP)
 - * Should be closer to 27,000 ft-lb with PIMP as a minimum life req'mt
- * Build "prototype" with conservative safety factors and test to determine realistic design loads (will probably weigh about 9,200 lbm)
- * Update loading conditions from test data
- * Evaluate alternative materials and cut margins
 - * Composites
 - * Fatigue test composite coupons representative of structure
 - * Trim composite structure per coupon fatigue test results
 - > Save about 150 lbm
 - * Titanium
 - * Evaluate titanium/carbon-fiber-epoxy hydrid
 - * Rough optimize using FEA
 - * Build and strain test weldment (maybe not titanium)
 - * Optimize wall and weld sections for life requirements
 - > Save about 150 lbm
 - * Hydraulic components
 - * Evaluate use of titanium as rod and liner material
 - * Determine availability of aluminum-lithium
 - * In 6 inch plate for front and midcradle manifolds
 - * In smaller sizes for actuator end caps, cannoneer 1 manifold, etc
 - * Evaluate practicality of replacing or supplementing Energy Recovery System with APU
 - > Save about 100 lbm
 - * Fire control
 - * Evaluate possibility of electronic fire control
 - * Basic Issue Items
 - * Determine practical minimum weight collection
- * Determine practical design weight with M198 range
 - > Probably about 8,800 lbm
- * Determine weight-range tradeoff
 - * Reduce range with light barrel option to 15km
 - * Reduce equilibration by changing accumulator
 - * Leave balance of structure alone to retain 30km version
- * Build prototype and test in two versions
 - * 9,000 lbm with 30km range (RAP)
 - > Start with 8,800 lbm LTHD
 - > Add 200 lbm for shields and thicker skins as required to increase durability
 - * 7,700 lbm with 15km range (nonRAP, zone 7 max)
 - * Lighter tube
 - > Save 1,000 lbm
 - * Different equilibration accumulator

- * Reduced assortment of basic issue items
 - > Save 100 lbm

Gimbal [D/140]

- * Use of titanium (low CTE) minimizes thermal growth delta versus cradle
- * Large rectangular shape with tapered box cross-section provides
 - + Upper traverse bearing, permitting elimination of heavy turntable bearing
 - + Good strength-to-weight structure to handle projectile spin-up torque
 - + Potential candidate for weight reduction through use of carbon-fiber-epoxy
- * Provides mounting for load tray track and fire control secondary trunnion

Heat Removal and Sustained Firing Rate

- * Thermal analysis should be performed to see if heat buildup in cradle is ok
- * Cradle probably should have holes in roof (see Cradle)
- * Most of hydraulic heat will probably materialize outside of cradle (see Compound Actuator Assembly)

Hydraulic leaks

- * Design efforts to minimize internally-induced leaks
 - * Closed system has to be charged to be filled, eliminating dirt ingestion during oil replenishment
 - * Control valves are poppet-style (zero-leakage, contaminant-resistant)
- * Design efforts to minimize externally-induced leaks
 - * Manifolds used to greatest extent possible
 - * Valves and accumulators are subplate or cartridge mounted
 - * No pipe thread (except for two pressure gauges)
 - * Lead time problem, better sealing thread would be used in production
 - * Lines are protected
 - * Tube bundles with (o'ring) push connections used when possible
 - * Front-cradle manifold to midcradle manifold
 - * Midcradle to Cannoneer 1 manifold
 - * Single lines are routed in out-of-the-way areas
 - Hoses must be routed from Cannoneer 1 manifold to gimbal (across trunnion)
 - This joint is not yet configured and thus could cause problems
- * Design efforts to minimize damage due to leaks
 - * Power on valve is just downstream of energy storage
 - * Shutting off valve seals oil in storage
 - * Ports to pressure gages are normally closed (no leak with broken gage)
 - * Lines to trails are fused (flow will stop if a line breaks)
 - * Equilibration system will not allow tube to fall even due to total loss of hydraulic fluid (see Actuators [BearLocs]).
 - * Breech can be opened and closed manually (see Breech)
 - * Projectile can be loaded manually (see Loading System)
 - * Primer Auto Loader can be operated manually (see Primer Auto Loader)
 - * Walking beam actuators, if fully extended, will not release load even with a total loss of hydraulic fluid (see Actuators [pin locks]).

Latch Position

- * Load Position Actuator (LPA) pushes against outer band with reservoir pressure at battery
- * Larger counterrecoil force holds cannon at battery

- * When cannon recoils, LPA follows outer band to LPA's stroke limit (3 feet)
- * Large flow passage from res'r accumulator allows high tracking velocity
- * With high zones, LPA brings c'recoiling cannon to rest with cushion
- * LPA has four cushions for recoil/c'recoil and load/battery conditions
 - * Cushions are easily modified
- * With low zones, Cannoneer 1 controls allow LPA to drive cannon out to load pos'n (36" from battery)

Lessons Learned

- * Good informal communications with Army personnel is crucial to fully understanding the potential technical and management problems associated with the design and end-use of Army materiel.
- * Surfaces problems (via proper channels) quickly.
- * Composite components necessitate early involvement and good informal communication between experienced design, manufacturing, materials, and analytical personnel.
- * A mortar-like howitzer provides a lightweight and stable structure, but some of the weight savings will be lost to solving the breech access problem.
- * Energy recovery can be used to solve the mortar-like howitzer breech access problem
 - + Reduce load on crew and crew requirements
 - + Reduce some hazards
 - Increase hardware cost
 - Probable decrease in soft degradation.

Loading System

- * Loading is performed at these conditions to allow 95th percentile Cannoneer 1 to insert propellant into breech from side.
 - * 0 to 600 mils
 - * with cannon 36" out of battery
- * Elevation system is designed to facilitate rapid tube depression and elevation to maintain firing rate [C/110]
 - Maximum firing rate is roughly one round every 18.8 seconds (M198 spec is one round every 15 seconds)
- * All loading controls are located at Cannoneer 1's manifold
 - + Cannoneer 1's manifold cannot be reached from breech.
 - Cannoneer 1 cannot hold bag in Swiss Notch with his/her hand.
 - * Not important, since all loading is done at 600 mils or below.
 - + Cannoneer 1 cannot close breech on his/her hand.
 - * The breech area is a safety hazard on the M198.
- * Loading Controls are arranged in natural sequence and orientation.
 - * Check energy level valve
 - + Pressure gage with settable external "energy dial"
 - * allows Cannoneer 1 to set dial according to volume indicators on counterrecoil accumulators, thus providing a ready reference as to whether or not there is enough energy to complete ramming cycle.
 - * Open/close breech valve
 - * Can only be operated at load position (36" out of battery)
 - * Can be manually opened and closed (see Breech)
 - * Ram with automatic return, slow ram, and manual retract valve
 - + Ram with auto return keeps Cannoneer 1 from accidentally releasing ram lever too soon (resulting in an inadequate ram)

- * Slow ram and manual retract used to position load tray behind breech
 - * for advancing Copperheads to breech (for manual ram)
 - * to catch stuck projectile during extraction
- * Move cannon to battery pos'n valve (from load pos'n, 36" out of battery)
 - * Releases actuator holding cannon out of battery in load position
 - * Can also be used to move cannon back to latch position when firing zone 4 and below because cannon does not recoil far enough to reach latch position.
- * Primer extraction and insertion valve (operates primer auto loader)
 - * Can only be operated at battery position
- * Lanyard valve (fires primer)
 - * Can only be operated at battery position
 - * Can be fitted with long lanyard and operated remotely (if off "safety")
- * Ramming actuator pulls tray forward, returns load tray to position behind recoil path
- * Shock absorbers on load tray decelerate tray when they impact breech face
- * Projectile momentum carries it into forcing cone
 - * Variant of flick ramming
 - * Longer acceleration distance should reduce structural deflection at point of release, possibly reducing variance of extraction force
- * Load Tray is U-shaped, hangs from overhead track
 - * Replaceable wear bars
 - * Ogive restraint limits forward travel of projectile when projectile is thrown into tray
 - * Ogive restraint lifts automatically when load tray hits breech face
 - * U-shaped leaf spring holds base during ram while allowing ease of loading.
- * Load tray hangs from three-section track
 - / A flexure was considered but dropped due to:
 - * conflicting need for flexibility (to minimize force required to bend), and
 - * rigidity (load tray stability), as well as
 - * strain necessary to make operational beyond material limits
 - * Forward section is suspended from cradle roof
 - * Rear section slides in a mount to the cradle
 - * Midsection connects forward section to rear section by hinge joints
 - * Removal of this section also provides hoist access to pull breech
 - * Vertical turns in track due to elevation (at hinge joints) necessitate
 - * Load tray hanging from mini-walking beam suspension (minimizing bump from vertical turns).
 - * Track thickness is varied to take up clearance during "final approach" to ram.
- * Load tray velocity is controlled by rammer control
 - * Expected to maintain $\pm 10\%$ velocity over temperature extremes
 - * Adjustable low speed section to get load tray into forward section
 - * Low speed section "time out" is based on oil volume used
 - * Adjustable high speed section to reach ram velocity before breech
 - / Mechanism to correlate ram velocity with QE was configured (connected to equilibration actuator) but not used when decision was made to limit loading height to 600 mils
 - * Adjustable retract velocity
- * Manual loading
 - * Disconnect load tray from ramming actuator (allowing tray to roll freely)
 - * Depress tube to 150 mils

- * Set projectile on tray, roll up to breech, and ram with long staff used to extract stickers

Mortar Configuration

- + Facilitates long recoil
- + Facilitates constant stroke recoil, simplifying recoil system
 - + Moves muzzle brake forward of crew positions relative to M198
 - + Reduces crew exposure to blast overpressure (6' or 2db)
 - Extends barrel farther from AZ/QE axis, possibly resulting in pointing accuracy problems
 - * Analysis suggests this problem is manageable
- + Provides ability to retract barrel for tow, providing compact package
 - + Improves road maneuverability in tow configuration
 - + Cradle protects crew from long recoil, a safety hazard [B/400pg7-2]
 - + Improves resistance to helicopter damage during helicopter lift, a current hazard with the M198 [B/400pg7-2]
- + Facilitates low trunnion height
 - + Minimizing jog in structure reacting horizontal recoil force into ground
 - Neg 5 deg QE is probably impractical
 - Requires secondary trunnion
 - * If electronic fire control is an option, the secondary trunnion may not be needed because the indirect fire control could be taken from transducers, while the direct fire scope could be mounted to the cradle.
- + Load path for high and low QE uses same structure
 - + Minimum structure, minimum weight
 - Wide platform/spade requires ground to conform to howitzer rather than traditional 3-point mount conforming to ground
- + Configuration can be resolved into large section tubular beams and/or trusses (platform, gimbal, cradle, trails)
 - + Maximum strength and stiffness to weight
 - + Compatible with composite structures
- + Forward trails
 - + Facilitates balanced weight distribution
 - + Minimum chance of rebound instability during counterrecoil
 - + Significantly shortens walking path between ammunition and loading points
 - + Pallets can be set up a few feet from load tray entrance without getting in way for speedshift (see Speedshift Assembly)
 - + Width near lunette reduces probability of rollover
 - Potential jackknifing problem when backing up
 - + May "catch" cannoneer that falls out truck, preventing him/her from going under wheels, a current M198 hazard [B/400pg7-2]
- Poor breech access
 - Necessitates providing a latch position for loading [B/500pg3]
 - Necessitates hydraulically powered rammer
 - Necessitates energy recovery system to power rammer (see Energy Recovery System)
 - Significantly complicates hydraulic system
 - + Recovered energy can be used to power other subsystems (see Energy Recovery System)
 - + Potential crew reduction

Muzzle Brake

- * M198 muzzle brake with integral lunette

- + Towing load path goes directly into barrel
- * Titanium casting
 - * New tooling required for lunette
 - * Weight reduction
 - * Improved corrosion resistance
- * Structural analysis
 - * Extensive structural analysis not warranted
 - * M198 brake limitation is wear, not strength
 - * Accuracy of structural analysis not sufficient to resolve difference as small as that between strength of titanium planned and steel used by M198
 - * If titanium brake fails, replace with M198 brake
 - * Make special "brake" just for towing
- * CTE mismatch with tube could cause basic concept problem
- * Analysis suggests CTE mismatch is not a problem [D/180]
- / High beta/blast-overpressure muzzle brake was considered but not used
- / Risk and magnitude of scope not worth gain (see Firing Stability)

Outer Breech Band

- * Transfers recoil force from recoil and counterrecoil rods to inner breech band.
- * Receives hydraulic signals from centers of recoil and counterrecoil rods and transfers them to the actuator that opens and closes the breech, the actuator that indexes the primer autoloader, and the actuator that fires the primer.
- * The outer breech band is made of aluminum for three reasons besides minimum weight and cost
 - * good CTE match with the midcradle manifold (avoid rod binding due to CTE mismatch).
 - * provides heat sink with respectable convection area to remove heat from the breech.
 - * good hydraulic manifold
- * The recoil and counterrecoil rods are connected to the outer breech band in such a manner to allow some float to eliminate the potential for binding as the rods are retracted to the battery position.

Platform

- * Use of titanium (low CTE) minimizes thermal growth delta versus gimbal
- * Large rectangular shape with boxed cross-section provides
 - + Upper traverse bearing, permitting elimination of heavy turntable bearing
 - + Good strength-to-weight structure to handle projectile spin-up torque
 - + For deep trail section (see Trails)
 - + Natural roll bar to protect against roll-over damage
 - + Potential candidate for weight reduction through use of carbon-fiber-epoxy

Primer Auto Loader

- * Twenty round drum
- * Primer actuator
 - * extracts spent primer
 - * indexes drum
 - * inserts new primer

- * Lanyard actuator
 - * fires primer using standard firing mechanism
- * Manual operation
 - * Primer actuator motion can be overridden by a hand lever
 - * Lanyard can be attached to firing mechanism

Rails (see Cannon)

Recoil System (see also Compound Actuator Assembly)

- * Long stroke minimizes recoil force
- * Stroke limit is set by barrel length
- * 105" total stroke
 - * 6" free recoil delays major loading until after shot ejection
 - * 96" effective recoil
 - * 3" overtravel cushion
- + Traditional orifice rod configuration
 - + Orifice rod profiled to provide constant load if fired from latch also provides fairly optimum profile for minimum hop under normal (fire from battery) condition.
 - + Free recoil delays major structural loads until after shot ejection
 - / Single orifice system was dropped due to complex interaction with Energy Recovery System [C/210]
- * Physically part of Compound Actuator Ass'y (see also Compound Actuator Assembly)
 - * Facilitates integration of recoil system with other hydraulic functions
 - * Recoil and counterrecoil actuator rods are hollow to minimize weight and to provide fluid signals to outer breech band (see Outer Breech Band)
 - * Counterrecoil provides input to energy recovery system (see Energy Recovery System)
 - * One counterrecoil actuator and counterrecoil accumulator are traditional.
 - * Second counterrecoil actuator acts as a single stage hydraulic pump.
 - * Second counterrecoil accumulator acts as a receiver for the second actuator.
 - * Recoil actuators used to extend barrel for firing, retract barrel for towing, from control on front-cradle manifold [see Mortar Configuration]
 - + Same function can also be used to stroke barrel into staff (held by rope to front-cradle manifold) to hydraulically remove stickers.
 - / Recoil force reduction through a mild form of soft recoil might be feasible
 - / Fire from the latch position would facilitate
 - some reduction in muzzle brake beta (and blast overpressure) and/or
 - some increase in charge
 - / Latch position with the long stroke of the FMC LTHD provides
 - * 69" cook off buffer
 - * 6" hangfire buffer
 - forward trails minimize chance of nosing over
 - * 30" soft recoil stroke

Spade

- * Effective spade area must be increased over M198 to maintain same skid-resistance due to weight reduction
- * Main spade is mounted beneath platform
 - + Simple load path
 - + Also serves as firing plate
 - + Easily replaced plastic inserts protect platform from rock damage
 - + Integration with platform eliminates loose piece
 - * Towing stability with walking beams facilitates raising CG enough to maintain adequate ground clearance without taking off spade
 - Three-point engagement with soil requires some compliance by soil
- * Main spade is titanium
 - + More ductile and higher strength than AlSiC
 - + Almost half the weight of steel
 - + Minimal corrosion problem
- * Perforations will probably be added
 - + Weight reduction
 - + Limit crack propagation
 - + Minimal impact on holding capability
- / Spades were considered [B/400pg4-25] for end of trails, but abandoned
 - + would aid in controlling skid
 - + ground engagement would help maintain lay during unavoidable rebound hop
 - potential lateral moment on trail is excessive

Speedshift Assembly

- * Mounts beneath cradle
- * Detach link, swivel down, attach link, speedshift
- * Reverse to stow speedshift
- LTHD does not speedshift about AZ, thus howitzer lay will be lost
- + Panoramic telescope has 6400 mil range, so howitzer can be relayed from neighboring howitzer (see Fire Control)
- + Ammunition, even though close to loading points, does not have to be moved to speedshift (see Mortar Configuration)

Thermal Growth Control and Anchors

- * Due to the mix of materials with different CTE's
 - * Thermal growth control is important to insure that excessive strain and stress doesn't damage structure during temperature excursions.
 - * Thermal anchors are critical where maintenance of critical dimensional features during temperature excursions is necessary.
- * Tube to collars and rails
 - * Collars are made of titanium where high strength is required and of AlSiC where strength requirement is less.
 - * Hoop stresses induced by tube temperature changes and internal pressurization is controlled by reliefs on the inside diameter of the collars.
 - * Stresses along the length of the rails is minimized by using AlSiC for the rails (vs aluminum) and controlled by allowing the collars to slip along the tube.
 - * Four keys in each collar anchor the collar to the tube to carry the projectile spin-up torque and maintain angular alignment.
 - * The (titanium) collar nearest the breech serves as locates the rails along the length of the tube (a thermal anchor).

- * Rails to compound actuator assembly
 - * X-axis control and anchor (using an xyz coordinate system as viewed from the breech).
 - * x-axis control is achieved by making the right flat and thus allowing it to float.
 - * x-axis is anchored by the "V" on the lower surface of the left rail thus traverse error within the rail mounting system due to temperature excursions is negligible
 - * Y-axis control and anchor
 - * sufficient vertical differential growth is provided by 0.010" bearing clearance.
 - * gravity sets the anchor at the bottom surface of the rails until projectile spin-up occurs, at which time the right rail anchor shifts 0.010" upward as the bearing load is shifted from the bottom to the top. The tube centerline moves about 0.007" in a parallel fashion about the "V" of the lower left anchor.
 - * Long span between way bearings (102") further minimizes already negligible tube lay errors.
- * Compound actuator assembly to cradle (see Compound Actuator Assembly for thermal growth considerations within the assembly) [B/700pg31thru33]
 - * Recoil force is taken out at front-cradle manifold
 - * Recoil actuator rods transfer load into manifold
 - * Manifold end loads cradle
 - * Vertical posts stick through cradle
 - * on centerline of cradle end edge to eliminate CTE z-axis mismatch
 - * Bottom of front-cradle manifold serves as x-y-z-axis anchor
 - * Bottom post is "headed" to tie compound actuator assy front to cradle
 - * Top post serves as x-axis anchor
 - * Projectile spin-up torque is taken out at midcradle manifold.
 - * Vertical posts stick through cradle to transfer torque.
 - * Bottom of midcradle manifold serves as x-y-axis anchor.
 - * Bottom post is "headed" to tie compound actuator assy rear to cradle.
 - * Top post serves as x-axis anchor.
 - * Post holes in cradle are slotted to facilitate z-axis growth
 - * Fit-as-assembly sequence facilitates alignment with AZ-QE axis
 - * Post removal facilitates compound actuator assembly removal without refitting
- * Trail assembly to cradle and platform (see Trail for thermal growth considerations within the assembly).
 - * Trail attachment to front-cradle manifold assembly accommodates z-axis growth.
 - * Trail attachment to platform serves as x-y-z-axis anchor.
 - * Torrington fabric thrust bearings locate y-axis
 - * Clearance in thrust bearings provides for thermal growth
- * Gimbal and platform
 - * both are titanium which, with its low CTE, are relatively stable dimensionally
 - * Torrington fabric thrust bearings locate y-axis
 - * Clearance in thrust bearings provides for thermal growth
- * Tube bundle to Cannoneer 1 manifold
 - * Push tubes (o'ringed slip joints) are used to accommodate the CTE mismatch between the cradle and the tube bundle (stainless steel)

Towing Stability

- * Preliminary analysis suggests stability of M198 will be exceeded (video tape provided to ARDEC 04Jun86) [C/230]
- * Walking beam multifunction capability (see Walking Beams) provides
 - * Lunette load (100 lbf) compatible with human factors even at min crew
 - * Lunette loading compatible with rule-of-thumb towing stability requirements (10% of towed load)
- * Overall LTHD width had to be increased (though still narrower than M198) to maintain tread width necessary for stability when walking beams were moved into trails (to eliminate separate dolly)
- * Latest walking beam configuration has not been analyzed for stability, although we do not think stability has been degraded by
 - * adoption of unequal length walking beams (see Walking Beams)
 - * addition of damping via walking beam actuators (see Walking Beams)
- * Rear of cannon is supported during towing
 - * Cannon is retracted for towing (equivalent to full recoil)
 - * As cannon is retracted, outer breech band engages towing guide mounted to inside bottom of cradle
 - * This is not documented in TDP

Trails

- + Deep section provides
 - + high stiffness-to-weight ratio, necessary to minimize rebound factor in firing stability (see Firing Stability)
 - * large storage area
- * Open truss
 - * Primarily carbon fiber epoxy members with titanium joints
 - * Matches CTE of cradle (important in stow configuration)
 - * Plus a titanium wheel bulkhead
 - + Thermal growth within structure is manageable
 - * Tied into cradle during towing to minimize loading caused by "bump and skid" (going around corner at high lateral g's and hitting bump)
 - * tie-in must be folded away during emplacement to keep from getting in way of cannoneer 1
 - * keeps Cannoneer 1 from experiencing amplified blast overpressure (from reflection)
- * Preloaded in firing position by threaded connection from platform
 - * Thread may be a problem with dirt (although probably no worse than pins used on M198)
 - Can only be opened to one angle

Valves

- * All valves are poppet-style (zero-leakage, contaminant-resistant)
- * Control valve handles must be depressed before position can be changed
- * AZ/QE (4-way) joystick
 - * force feedback throttling
 - * provides "feel"
 - * provides automatic release and relock of BearLocs
 - * May enhance aiming accuracy and speed from "video game skills" of current generation of soldiers

Walking Beams

- + Reduce road shock input
 - + Combination shock absorbers/hydraulic actuators dampen road shock
 - + Simple control valve mounted on each actuator (one per wheel)
 - + Fuzed to main circuit to keep a leak in walking beam actuators from bleeding down main system
 - Problem from high flow rates in actuator possible from road shock input have not yet been resolved
 - / Accumulator in actuator rod, possibly with pilot-operated two-way valve in piston, limiting oil consumption during emplacement while opening volume to accumulator during tow (requires change in actuator control valve porting pattern)
- + Facilitate raising CG sufficiently to make spade integral to platform
 - + Spade can be removed if more ground clearance than M198 is req'd
- + Moved from separable dolly to integral with trail [B/500pg9] [F/140]
 - + Dolly was hard to align and maneuver
 - + Eliminate loose piece
 - + Dolly would not have been compatible with matured design of cradle
- + Provide multiple additional functions
 - + Meet human factors specs for lunette load with minimum crew while putting sufficient weight on lunette during towing for stability (see Towing Stability)
 - + When locked together (forward and rearward part of walking beam linked)
 - + Rock forward to reduce load on lunette to 100 lbf
 - + Rock backward to increase angle of departure
 - + Rock flat tire up to change tire
 - + Lock in position to run on good tire when other is flat
 - + When not locked together
 - + Lift into trail during firing, increasing stabilizing moment
 - + Lower rear wheels to extract spade
 - + Lower front wheels to balance howitzer during speedshift
- + Provide ability to drop 763 lbf in an emergency
 - + Break or cut fluid connections and release pivots
- * Unequal length walking beams adopted
 - + Rear wheel set to maximize angle of departure
 - + Front wheel set to provide manageable lunette load for emplacement/displacement
 - + Design facilitates easy modification to adjust actual lunette weight after assembly
 - + Space between wheels set to make sure rocks were unlikely to bind up between them
 - + Walking beam pivot set back to maximize size of rock front wheel can go over before binding.
 - + Improves C130 roof clearance [B/200pgHT-3andHT-5] [B/400pg4-7]
- * Service brakes on all four wheels
 - * Two sets per wheel to achieve envelope requirement necessary to retract into trail
 - + Improved redundancy
- * Parking brakes on forward wheels only (used with light lunette load)
- * Axle is pulled (like front wheel of motorcycle) to change wheel or tire
- * Operation of actuators from a pressurized reservoir facilitates lowering wheels during displacement in below freezing weather (a problem with the gravity-fed reservoir on M198)

A/120

PHASE II
FORMALLY NOTED
OPENING DEFICIENCIES

VICATINNY (86-732)

PRELIMINARY

EVALUATION TEAM COMMENTS

FOR FMC

RELE - FOMENT JS WERE
YORK - SUPPLY INFO?

BART'S
VIARELL
COPY

FMC System Operability

PROJECT
BMT

Strong Points

o Configuration presents a compact package which greatly enhances transportability.

o Theoretically excellent cross-country capability. (reference computer simulations.)

o System will, theoretically, significantly reduce the labor intensity associated with operating towed artillery.

Weak Points-

SO-1 o The system appears to be 100% hydraulically controlled and operated. Minor hydraulic problems and or combat damage could easily cause this weapon to become totally inoperable.

SO-1

(SO-2 o Hydraulic system reliability does not have a good track record in existing ARMY artillery systems.

SO-2

SO-3 o Assuming stored energy is insufficient to emplace the weapon, the time required to manually pump up the system is viewed as an operational deficiency.

SO-3

SO-4 o The secondary or offset trunnion, appears to be vertically displaced by approximately 4 ft. The ability to effectively engage direct fire targets is questionable due to parallax conditions between the bore and direct fire sight centerlines.

SO-4

SO-5 o The configuration necessitates the bore centerline to be approximately 18 inches from ground level. The ability to effectively engage direct fire targets is questionable at this height due to trees, brush, rocks etc., between the howitzer and target.

SO-5

SO-6 o The firing crew is totally separated from the breech area. Visual inspection to verify complete charge bag insertion is impossible. This is viewed as a safety hazard and an operational deficiency.

SO-7 o Visual inspection of the bore area and verification of bore clear procedures are extremely difficult; if not impossible.

SO-8 o During blackout operations, no visual verification of the loading procedure is possible.

SO-9 o During daylight hours no visual verification of ~~any~~ engagement with the breech, correct ramming of the projectile, and correct position of the powder charge for ramming is possible.

LOAD TRAY

SO-10 o Power ramming a powder charge is viewed as a high risk operation. The charge is not rigid, and ripping or tearing the bag is possible if charge alignment is off. In addition, no visual verification by the crew is possible if the charge "hangs up".

SO-11 Mechanical ramming by pushing on the powder charge igniter pad is viewed as high risk.

SO-12 o Bore swabbing and breech clearing through water spray and brush is totally unacceptable.

SO-13 o No discussion of system disengagement with prime mover is discussed.

SO-14 o Manually "jockeying" around the dolly is viewed as difficult on uneven terrain, considering the weight of this item.

FMC Design Adequacy and Produceability

+P-1 o The effect the metal liner has on the composite structure in the recoil cylinders must be addressed. Thermal coefficients of expansion must be considered in order to preclude de-laminations. *Yell to provide info?*

o Several problems exist in the slide concept configuration. The thin wall honeycomb sandwich construction is both impact and moisture sensitive. Reference to acceptable aircraft construction does not indicate adequacy for howitzers.

o ^{ul} Extruded rails are very risky. *will they be wavy? maybe extended S/C/M rails?* The likelihood of premature failure due to matrix cracking at the corners is high. This is caused by inability of the fibers to reinforce the corners. The concept of making four plates and joining them with preformed corners is inadequate. Filament winding in this area would produce a superior structure. Galvanic corrosion and adhesive selections should be addressed.

o Honeycomb core construction in the trails is a concern due to impact damage and moisture absorption. Pre-formed woven corners seem inadequate. Complexity and cost would be high with this concept. The choice of a factor of safety approach is not as adequate as hot/wet property data. *also need statistical distribution.*

o The choice of graphite epoxy skin with aluminum honeycomb core in the platform area invites two potential problems. One is the moisture effects on honeycomb construction and two is the shielding of aluminum from graphite to prevent galvanic corrosion. Hand lay-up and autoclave cure is reasonable for these parts.

Tape wrap to simulate filament winding?

o The "claws" are constructed as described above and similar problems are foreseen. The claw should be designed for damage tolerance since it is expected to interface with the ground. Graphite epoxy skin is inadequate for this purpose. ^{20/14}

o The "backbone" is constructed using a hand lay-up procedure rather than being filament wound. This is considered a poor approach for this component. Removing the mandrel to form a concave section may result in a wrinkled, void filled structure that will not possess the desired mechanical properties.

o All components should be inspectable by ultrasonic techniques. No indication of inspecting for moisture absorption exists. This must be addressed.

o The bolted joint method of integration is acceptable; however, corrosion and sealing of the holes from moisture should be addressed.

o Bulkiness in trail design is also a concern. It is not clear what weight optimization process ruled out a more reasonable selection of dimensions. The construction does not seem to take damage tolerance and environmental degradation factors into account.

FMC Structural Verification

o Beam stress calculations on the supporting trails which allow 70kpsi in a quasi-isotropic lay up of graphite epoxy seem suspect. The allowed stress can not possibly be greater than 50kpsi for a quasi-isotropic lay up, even before introducing moisture effect degradation factors.

o There is also a disregard for environmental effect, including hot/wet conditions and impact damage degradation effects.

o The claimed skin thickness in the trail beam of .019" in the sandwich flanges is suspect.

o The produced rail design is suspect. The corners are vulnerable to cracking when the structure is loaded in bending. ^(INSIDE SIDE)

o The graphite epoxy skin of the claws appears to be vulnerable. This area should be addressed utilizing a damage tolerant design criteria.

o Strength calculations are questionable because of the dry room temperature values used. The knockdown factors are generated from the Tsai-Wu equation; however, the stresses calculated have sketchy rationale. The documentation does not indicate how these stresses are derived.

o No justification has been given for the size of the trails.
Collaboration on the design methodology of these components is desired.

FMC System Stability

Strong Points

o Excellent towing stability analysis through computer simulation.

Weak Points

o A trapezoidal recoil force profile is most desirable but not always obtainable. Maintaining this profile through 8 and one half feet of recoil travel will be difficult, especially in light of the "energy taps" employed for the hydraulic system. Temperature induced gas pressure changes, as they affect recoil force, appear not to be adequately addressed. A "sensitivity" analysis would be helpful.

o Counter-recoil stability is mentioned but not fully investigated.

o Rifling torque appears not to be included in stability computations.

FMC Cannon / Ammo

Strong Points

o It appears cannon system is compatible with all 155MM ammunition.

o No adverse impact is anticipated on range or on range precision with the configuration.

Weak Points

o Cannon interface was not adequately determined until after the phase 1 final review.

o The automatic breech opening mechanism for this design has not been determined.

o The primer feed mechanism has not been adequately defined.

FMC - Recoil Mechanism

- o The effects of the external cylinders used for power recovery and storage on the recoil cycle has not been addressed.
- o The manufacturing of an effective ten foot recoil mechanism is of great concern.
- o A trapezoidal shape recoil force vs. time curve is utilized for all analyses. A more conservative approach in which some room is allowed for non-ideal circumstances is preferred.

FMC - Organization

- o There appears to be a reluctance by FMC management to bring forth supporting documentation of their efforts. This position hampers not only the FMC effort, but the program as well by not allowing adequate monitoring of progress made. A change in this area will be most mutually beneficial and desirable.
- o There seems to be a lack of coordination between CEL and Northern Ordnance. It is felt that the FMC composite experience is very limited - perhaps to that associated with the Bradley Fighting Vehicle. The primary emphasis and design philosophy brought forth in the Light Weight Towed Howitzer is that of metal construction. If this philosophy and outlook does not change, grave design errors are likely to occur.
- o It is unclear why this effort has both a program manager and project manager. Discussion of this question with Ms. Tia Stackland resulted in a poor explanation.
- o The entire cannon interface portion of this program was poorly executed.
- o Program has undergone a shakeup in management midway through Phase 1. This is apparent in the organization of this entire program. Numerous significant design changes up to the conclusion of Phase 1 indicate that personnel are not clear on their direction.
- o Technical personnel seem well motivated however, numerous design changes apparent at the final review indicate they also are unclear of their direction.

FMC - Quality Assurance

The inspection facilities that FMC has shown are predominantly laboratory testing apparatus. They are able to test coupons and tensile samples, but it is felt that large, full size, howitzer structures are going to pose a problem.

The honeycomb composite structure used throughout the concept has a moisture absorption characteristic that results in decreased mechanical performance. Because the proposed outside skin is an organic composite it will be very difficult to inspect for moisture content.

FMC has given little consideration to producibility aspects - the hand lay-up techniques proposed are very expensive.

The loader feeder for primers is a complicated unproven device - this can be a major RAM problem.

The cantilevering of the gun may cause fire control problems because of vibrational modes and/or instabilities.

The skin of the so called "claws" is proposed to be graphite epoxy. It is hard to foresee this construction surviving the type of abuse it will receive.

The equilibration cables seem to be a potential RAM problem.

The P.A. plan is scarcely addressed.

It appears that little consideration has been given to the formulation of an impact damage assessment.

There is no indication of any thought given to the delamination problem which may occur from expansion between the over wrapped cylinders and the composite wrapping.

The recoil slides/cradle is viewed as having three serious potential problems:

1. Degradation by moisture absorption.
2. The method utilized for joining the four sides appears very similar to ones used for metal fabrication. This structure would seem to be much more efficient if filament wound.
3. In the chosen configuration, the glass or graphite pultrusions that are to make up the slides seem very prone to develop cracks due to a lack of reinforcement inherent in the pultrusion process. In addition, residual stresses in the material due to resin shrinkage may be enough to initiate cracks.

NOD (8608001)
PICATINNY (8608001)
PACEL (8608001)

Date: 4 August 1986
To: Distribution (See responsibilities below)
From: Herb Theumer *th*
Subject: Evaluation Team Comment Replies

Attached is a coded copy of the Evaluation Team Comments received at the kick-off meeting for Phase II at ARDEC.

As discussed earlier, we have ample opportunity to reply to these comments by either explaining discrepancies or misunderstandings, or by detailing another approach that may be more appropriate to use than the one originally proposed.

We will share the reply effort by assigning responsibility for various sections to different team members. That does not mean that everyone will help as needed.

The responsibilities are as follows:

System Operability (SO)	Herb Theumer/ Bart Anderson
Design Adequacy and Produceability (DAP)	Bruce Zierwick
Structural Verification (SV)	Bruce Zierwick
System Stability (SS)	Scott Dacko/ Jeff Ireland
Cannon/Ammo (CA)	Bart Anderson
Recoil Mechanism (RM)	Jeff Ireland/ Scott Dacko
Organization (O)	Dave Peterson/ Herb Theumer
Quality Assurance (QA)	Herb Theumer

We will state each comment and follow it with our reply in order to have adequate cross-reference to each section and each comment using the coding shown on the following pages.

The schedule for this effort is as follows:

15 August	draft comments to Herb Theumer for compilation and team review
29 August	copies sent to ARDEC for review prior to meeting
5 September	Meeting to discuss replies at ARDEC

The first project review meeting for Phase II will be tentatively held at ARDEC on 29 and/or 30 October.

This would require an internal review meeting and dry run about 16 October. Let's plan to make these dates.

Preliminary Evaluation Team Comments for FMC

FMC System Operability

- SO-1 The system appears to be 100% hydraulically controlled and operated. Minor hydraulic problems and/or combat damage could easily cause this weapon to become totally inoperable.
- SO-2 Hydraulic system reliability does not have a good track record in existing ARMY artillery systems.
- SO-3 Assuming stored energy is insufficient to emplace the weapon, the time required to manually pump up the system is viewed as an operational deficiency.
- SO-4 The secondary or offset trunnion appears to be vertically displaced by approximately 4 ft. The ability to effectively engage direct fire targets is questionable due to parallax conditions between the bore and direct fire sight centerlines.
- SO-5 The configuration necessitates the bore centerline to be approximately 18 inches from ground level. The ability to effectively engage direct fire targets is questionable due to trees, brush, rocks, etc. between the howitzer and target.
- SO-6 The firing crew is totally separated from the breech area. Visual inspection to verify complete charge bag insertion is impossible. This is viewed as a safety hazard and an operational deficiency.
- SO-7 Visual inspection of the bore area and verification of bore clear procedures are extremely difficult if not impossible.
- SO-8 During blackout operations, no visual verification of the loading procedure is possible.
- SO-9 During daylight hours no visual verification of dolly (loading tray) engagement with the breech, correct ramming of the projectile, and correct position of the powder charge is possible.
- SO-10 Power ramming a powder charge is viewed as a high risk operation. The charge is not rigid, and ripping or tearing the bag is possible if charge alignment is off. In addition, no visual verification by the crew is possible if the charge "hangs up".

- SO-11 Mechanical ramming by pushing on the powder charge igniter pad is viewed as high risk.
- SO-12 Bore swabbing and breech clearing through water spray and brush is totally unacceptable.
- SO-13 No discussion of system disengagement with prime mover is discussed.
- SO-14 Manually "jockeying" around the dolly is viewed as difficult on uneven terrain, considering the weight of this item.

FMC Design Adequacy and Produceability

- DAP-1 The effect the metal liner has on the composite structure in the recoil cylinders must be addressed. Thermal coefficients of expansion must be considered in order to preclude de-lamination.
- DAP-2 Several problems exist in the slide concept configuration. The thin wall honeycomb sandwich construction is both impact and moisture sensitive. Reference to acceptable aircraft construction does not indicate adequacy for howitzers.
- DAP-3 Poltruded rails are very risky. The likelihood of premature failure due to matrix cracking at the corners is high. This is caused by inability of the fibers to reinforce the corners. The concept of making four plates and joining them with preformed corners is inadequate. Filament winding in this area would produce a superior structure. Galvanic corrosion and adhesive selections should be addressed.
- DAP-4 Honeycomb core construction in the trails is a concern due to impact damage and moisture absorption. Pre-formed woven corners seem inadequate. Complexity and cost would be high with this concept. The choice of a factor of safety approach is not as adequate as hot/wet property data.
- DAP-5 The choice of graphite epoxy skin with aluminum honeycomb core in the platform area invites two potential problems. One is the moisture effects on honeycomb construction and two is the shielding of aluminum from graphite to prevent galvanic corrosion. Hand lay-up and autoclave cure is reasonable for these parts.
- DAP-6 The "claws" are constructed as described above and similar problems are foreseen. The claw should be designed for damage tolerance since it is expected to interface with the ground. Graphite epoxy skin is inadequate for this purpose.

- S0-7 The "backbone" is constructed using hand lay-up procedure rather than being filament wound. This is considered a poor approach for this component. Removing the mandrel to form a concave section may result in a wrinkled, void filled structure that will not possess the desired mechanical properties.
- S0-8 All components should be inspected by ultrasonic techniques. No indication of inspecting for moisture absorption exists. This must be addressed.
- S0-9 The bolted joint method of integration is acceptable; however, corrosion and sealing of the holes from moisture should be addressed.
- S0-10 Bulkiness in trail design is also a concern. It is not clear what weight optimization process ruled out a more reasonable selection of dimensions. The construction does not seem to take damage tolerance and environmental degradation factors into account.

FMC Structural Verification

- SV-1 Beam stress calculations on the supporting trails which allow 70 kpsi in a quasi-isotropic lay-up of graphite epoxy seem suspect. The allowed stress cannot possibly be greater than 50 kpsi for a quasi-isotropic lay-up, even before introducing moisture effect degradation factors.
- SV-2 There is also a disregard for environmental effect, including hot/wet conditions and impact damage degradation effects.
- SV-3 The claimed skin thickness in the trail beam of .019" in the sandwich flange is suspect.
- SV-4 The produced rail design is suspect. The corners are vulnerable to cracking when the structure is loaded in bending.
- SV-5 The graphite epoxy skin of the claws appears to be vulnerable. This area should be addressed utilizing a damage tolerant design criteria.
- SV-6 Strength calculations are questionable because of the dry room temperature values used. The knockdown factors are generated from the Tsai-Wu equation; however, the stresses calculated have sketchy rationale. The documentation does not indicate how these stresses are derived.

SV-7 No justification has been given for the size of the trails. Collaboration on the design methodology of these components is desired.

FMC System Stability

SS-1 A trapezoidal recoil force profile is most desirable but not always obtainable. Maintaining this profile through 8 and a half feet of recoil travel will be difficult, especially in light of the "energy taps" employed for the hydraulic system. Temperature induced gas pressure changes, as they affect recoil force, appear not to be adequately addressed. A "sensitivity" analysis would be helpful.

SS-2 Counter-recoil stability is mentioned but not fully investigated.

SS-3 Rifling torque appears not to be included in stability computations.

FMC Cannon/Ammo

CA-1 Cannon interface was not adequately determined until after Phase I final review.

CA-2 The automatic breech opening mechanism for this design has not been determined.

CA-3 The primer feed mechanism has not been adequately defined.

FMC Recoil Mechanism

RM-1 The effects of the external cylinders used for power recovery and storage on the recoil cycle has not been addressed.

RM-2 The manufacturing of an effective ten foot recoil mechanism is of great concern.

RM-3 A trapezoidal shape recoil force vs. time curve is utilized for all analyses. A more conservative approach in which some room is allowed for non-ideal circumstances is preferred.

FMC Organization

- O-1 There appears to be a reluctance by FMC management to bring forth supporting documentation of their efforts. This position hampers not only the FMC effort, but the program as well by not allowing adequate monitoring of progress made. A change in this area will be most mutually beneficial and desirable.
- O-2 There seems to be a lack of coordination between CEL and Northern Ordnance. It is felt that the FMC composite experience is very limited - perhaps to that associated with the Bradley Fighting Vehicle. The primary emphasis and design philosophy brought forth in the Light Weight Towed Howitzer is that of metal construction. If this philosophy and outlook does not change, grave design errors are likely to occur.
- O-3 It is unclear why this effort has both a program manager and project manager. Discussion of this question with Ms. Tia Stackland resulted in a poor explanation.
- O-4 The entire cannon interface portion of this program was poorly executed.
- O-5 Program has undergone a shakeup in management midway through Phase I. This is apparent in the organization of this entire program. Numerous significant design changes up to the conclusion of Phase I indicate that personnel are not clear on their direction.
- O-6 Technical personnel seem well motivated however, numerous design changes apparent at the final review indicate they also are unclear of their direction.

FMC Quality Assurance

- QA-1 The inspection facilities that FMC has shown are predominantly laboratory testing apparatus. They are able to test coupons and tensile samples, but it is felt that large, full size, howitzer structures are going to pose a problem.
- QA-2 The honeycomb composite structure used throughout the concept has a moisture absorption characteristic that results in decreased mechanical performance. Because the proposed outside skin is an organic composite it will be very difficult to inspect for moisture content.

- QA-3 FMC has given little consideration to producibility aspects - the hand lay-up techniques proposed are very expensive.
- QA-4 The loader feeder for primers is a complicated unproven device - this can be a major RAM problem.
- QA-5 The cantilevering of the gun may cause fire control problems because of vibrational modes and/or instabilities.
- QA-6 The skin of the so called "claws" is proposed to be graphite epoxy. It is hard to foresee this construction surviving the type of abuse it will receive.
- QA-7 The equilibration cables seem to be a potential RAM problem.
- QA-8 The P.A. plan is scarcely addressed.
- QA-9 It appears that little consideration has been given to the formulation of an impact damage assessment.
- QA-10 There is no indication of any thought given to the delamination problem which may occur from expansion between over wrapped cylinders and the composite wrapping.
- QA-11 The recoil slides/cradle is viewed as having three serious potential problems:
 - 1. Degradation by moisture absorption.
 - 2. The method utilized for joining the four sides appears very similar to ones used for metal fabrication. This structure would seem to be much more efficient if filament wound.
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A/130

PHASE II
FORMAL RESPONSE
TO
OPENING DEFICIENCIES

PICATINNY (860829)

BREIS
MURKUP

F M C
R E P L I E S
to

PRELIMINARY
EVALUATION TEAM COMMENTS

FMC Corporation
Columbia Heights Center (CHC)
3989 Central Avenue
Minneapolis, Minnesota 55421

29 August 1986

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FMC System Operability

SO-1 Comment - The system appears to be 100% hydraulically controlled and operated. Minor hydraulic problems and/or combat damage could easily cause this weapon to become totally inoperable.

Reply - The system is essentially 100% hydraulically controlled and operated. The following steps have been taken, to date, to minimize the susceptibility to minor problems and/or combat damage that might render this weapon inoperable. The major reason for selecting hydraulic control is that it provides a design that is significantly lighter than other alternatives investigated.

1. All major pressure vessels are enclosed within the slide.
 - Improves protection.
2. All major actuators (except recoil and counterrecoil) are kevlar-wrapped. Recoil and counterrecoil are not currently kevlar-wrapped due to heat rejection concerns.
 - Improves resistance to external damage resulting in internal malfunction.
3. All accumulators are kevlar-wrapped.
 - Improves resistance to externally-induced internal

damage and reduces or eliminates shrapnel due to bullet-induced explosion.

4. Equilibration actuators have composite shields.

- Improves protection.

5. Connection of equilibration accumulator to equilibrators actuator is through a slip ring into a manifold.

- Improves structural integrity and resistance to shock loading.

6. Equilibration accumulator is of bellows type.

- Improves resistance to external damage resulting in internal malfunction.

7. All valving is manifold mounted (cartridge or subplate).

- Improves structural integrity and resistance to shock loading.

8. Major arteries between manifolds are bundled and kevlar-wrapped (front of slide to rear of slide and rear of slide to mid-slide).

- Improves structural integrity and resistance to shock loading.

9. Pipe threads are not used.

- Improves structural integrity and resistance to shock loading.

10. Hydraulic circuit breakers protect the recoil and equilibration systems from fluid loss due to loss of fluid in other sections of the hydraulic system.

11. Dual hand-pumps are provided (one for gunner, one for assistant gunner).

- Provides redundancy.

12. "Feather touch" controls are planned in critical control areas.

- Improves resistance to hydraulic system-induced shock loading.

13. Ultra-fine, zero bypass filter (high delta psi element).

- Does not allow contaminated fluid to enter system.

14. Dynamic analysis of hydraulic system is planned for Phase II.

- Reduces probability of "water-hammer" and resultant hydraulic system-induced shock loading.

As specifics relative to RAM-D and degraded modes develop, additional measures may be taken. They include:

1. Select special hose configurations and materials to maximize durability.
2. Provide ability to isolate selected sections of hydraulic system and provide two-20' hoses to facilitate external hydraulic circuitry in the event of artery damage.
3. Employment of redundant systems for critical functions (redundancy levels in jet aircraft typically vary from 2 to 5).

S0-2 Comment - Hydraulic system reliability does not have a good track record in existing ARMY artillery systems.

Reply - See S0-1.

S0-3 Comment - Assuming stored energy is insufficient to emplace the weapon, the time required to manually pump up the system is viewed as an operational deficiency.

Reply - The system can be emplaced for firing by locking out the energy recovery accumulator and using the hand pump to extend the platform and elevate the cannon. (Takes 2 men approximately 2 minutes.) The time required for manual pumping is approximately 10% more than with a mechanical actuator. The procedure for locking out the accumulator is defined in the Appendix A1, page 4, under the hand pump.

S0-4 Comment - The secondary or offset trunnion appears to be vertically displaced by approximately 4 ft. The ability to effectively engage direct fire targets is questionable due to parallax conditions between the bore and direct fire sight centerlines.

Reply - The fact that the tube is further removed from sight results in parallax error. The parallax error, which results from differences of carriage pitch, is negligible. The correction for parallax is included in the direct fire range plate. At 10° carriage elevation the parallax error is 0 and at 0° and 20° carriage elevation the error is

maximum (approximately 8 inches). The bore sight template is included in Appendix B-4.

S0-5 Comment - The configuration necessitates the bore centerline to be approximately 18 inches from ground level. The ability to effectively engage direct fire targets is questionable due to trees, brush, rocks, etc. between the howitzer and target.

Reply - Discussion of the problem:

Since the fire control is mounted on a "secondary trunnion" that is at the same trunnion height as the M198, the problem has been assumed not to be seeing the target, but rather the projectile trajectory. The trunnion height of the FMC LTHD, at 18 inches, is 30 inches below the four foot M198 trunnion height. Thus, the trees, brush, and rocks that will cause the problem will be those that would have been less than 30 inches below the trajectory of direct fire from an M198 at zero QE.

Because the FMC LTHD trunnion is further from the muzzle, this delta goes to zero at QE's above 12 deg. Thus, a second qualifier is for QE's below 12 degrees.

Reason for low trunnion height:

The FMC LTHD trunnion was dropped to 18 inches for firing and towing stability. While the reduced trunnion height is very beneficial toward achieving firing stability, achieving towing stability was a primary driver in reducing the trunnion height.

Initial towing stability analyses clearly indicated the criticality of lowering the center of gravity, particularly in around-the-curve stability while hitting a bump. Widening the wheels (beyond 96 inches to the 110 inch M198 width) addressed the around-the-curve stability, but it also adversely impacted towing mobility and loading onto C130 aircraft. Thus, the decision to drop the trunnion to 18 inches was made. Towing stability now appears (theoretically) to be superior to the M198 in straight lines as well as around curves (although additional stability is still available by increasing the width to over eight feet).

The Trade-Off:

Towing stability likely to be more critical than a direct fire trajectory 30 inches below that of the M198 at zero QE (15 inches at QE's of 6 deg)?

While at Fort Sill watching M198's being emplaced, we

observed the wheel of one of the three units bounce almost a foot off the ground due to a small bump, at a speed of 4-5 mph, at approximately a 65 foot turning radius, during positioning in the field.

Summary - Given the current doctrinal employment methods, we have found insufficient justification to warrant trading towing stability for 30 inches of trajectory height (at zero QE) to miss bushes, rocks, and trees while engaging a direct fire target.

SO-6 Comment - The firing crew is totally separated from the breech area. Visual inspection to verify complete charge bag insertion is impossible. This is viewed as a safety hazard and an operational deficiency.

Reply - The firing crew is totally separated from the breech area when the maximum rate of fire procedure is necessary. Visual inspection to verify complete bag charge insertion is difficult, thus the Rammer Position gage is provided to indicate when the ram is fully extended. See Appendix B2.

Under the continuous rate of fire procedure option, a cannoneer is stationed beside the breech. Swabbing, bore cleaning and bag insertion are then performed manually.

See Appendix B3.

Tests performed at FMC support the feasibility of power positioning a bag charge. During a study conducted at Northern in 1983, a 155mm Howitzer Brassboard Autoloader was modified to test the concept of mechanically positioning bagged propellant. In addition to determining friction characteristics between the propellant bags and the autoloader components, the test program determined whether the bags could withstand the wear and tear of mechanical handling.

Results include:

- o The various ramming tests on the bagged propellants demonstrated that the speeds and impacts encountered caused no apparent damage to the bag material. No ripping or tearing occurred; and the tie strips did not untie, either in the long charge or short charge configurations. Several ram cycles were completed with twisted tie strips with no problem.
- o It was possible to demonstrate consistently repeatable seating distances using a buffing orifice which provides 1/4 G deceleration.
- o The bags were durable enough to withstand the speeds

necessary to meet the ramming cycle time constraints.

- o When ramming tests were conducted with a large rammer pawl-to-bag gaps (up to 20 inches), the ramming impact produced no ill-effects on the propellant bags.
- o Based upon the testing accomplished in this task, it seems that mechanical ramming of bagged propellant is quite feasible. Since these tests did not indicate how sensitive the actual propellant chemicals will be, further testing may be required. If necessary, however, softer starts in the ram cycle can be accomplished by slight changes in the ramming system configuration. Bag "hang-ups" can be eliminated or minimized with a configuration with smooth surface transitions.
- o Test results proved the feasibility of the following propellant rammer force/time profile:

3.0 G acceleration for 0.10 sec, 0.30 G
deceleration for 1.05 sec. Total stroke length:
70 inches, total time: 1.15 sec.

The above results were summarized from FMC E.C. 1165,
"155mm Howitzer Brassboard Autoloader (DSWS), Determination
of Sliding Friction Coefficients for Bagged Propellant," 10

August 1983, and is available upon request. Slow-motion films of the tests are also available.

S0-7 Comment - Visual inspection of the bore area and verification of bore clear procedures are extremely difficult; if not impossible.

Reply - See S0-6.

S0-8 Comment - During blackout operations, no visual verification of the loading procedure is possible.

Reply - Operation recommended here is the same as discussed in the continuous rate of fire procedure discussed in S0-6. Visual verification for blackout is accomplished manually, similar to what is presently done on the M198.

S0-9 Comment - During daylight hours no visual verification of dolly (loading tray) engagement with the breech, correct ramming of the projectile, and correct position of the powder charge for ramming is possible.

Reply - The rammer cannot be positioned for ramming if the loading tray is improperly aligned with the breech. The rammer will not ram--and will be so indicated by the Ram

Position Pressure Gauge--if the rammer position is incorrect. The ram position pressure gauge will indicate full seating of the projectile.

For continuous rate of fire operation, the cannoneer manually installs the charge and monitors the position.

For maximum rate of fire operation, if the charge holder is incorrectly positioned, the rammer will not move and the ram position pressure gage will so indicate.

S0-10 Comment - Power ramming a powder charge is viewed as a high risk operation. The charge is not rigid, and ripping or tearing the bag is possible if charge alignment is off. In addition, no visual verification by the crew is possible if the charge "hangs up".

Reply - See S0-6.

S0-11 Comment - Mechanical ramming by pushing on the powder charge igniter pad is viewed as high risk.

Reply - See S0-6.

SO-12 Comment - Bore swabbing and breech clearing through water spray and brush is totally unacceptable.

Reply - In light of the problems associated with water spray at subzero temperatures, we have modified our concept for bore swab:

For the continuous rate of fire operation, the cannoneer will manually swab and check for a clear breech as indicated in SO-6. For maximum rate of fire operations, the forward end of the rammer has a bristle-brush that brushes the chamber walls when the projectile is being rammed and when the rammer is being retracted, as discussed in Appendix A1-8, Ram.

SO-13 Comment - No discussion of system disengagement with prime mover is discussed.

Reply - Disengagement from the prime mover is accomplished by extending the platform (in order to reduce tongue weight) and then manually disconnecting. This procedure is discussed in detail in Appendix B1.

SO-14 Comment - Manually "jockeying" around the dolly is viewed as difficult on uneven terrain, considering the weight of this item.

Reply - The dolly weighs approximately 665 pounds of which about 1/3 is rolling weight. For a speedshifting operation, it is necessary to move the dolly forward approximately 20 feet. For direct fire operations below 100 mils, the dolly must be moved forward and to the side. This movement will be more difficult on uneven terrain and alternate methods of movement, such as using a cable to raise two wheels to simplify rotations, are being investigated.

FMC Design Adequacy and Producibility

DAP-1 Comment - The effect the metal liner has on the composite structure in the recoil cylinders must be addressed. Thermal coefficients of expansion must be considered in order to preclude delaminations.

Reply - The effect of the differences in thermal expansion coefficient of the steel liner versus the composite overwrap in the York Aerospace hydraulic cylinders is the issue. York Aerospace (a potential subcontractor) claims to have had no problems with this in any of their previously designed cylinders. The question is then, has York built cylinders in similar sizes to those proposed on the LTHD. Part size is in direct proportion to any differential expansion problems that may occur. York Aerospace claims that they have built many accumulators with the same diameter as those on the LTHD but only up to about half the length.

York Aerospace has, to date, successfully dealt with thermal expansion problems by developing a process by which proper tension in the composite overwrap is used to keep the steel liner in radial compression at all pressure and temperature extremes. Accumulators they have built for

aircraft have gone through qualification testing in which they were cycled 1,062,000 pressure cycles at temperatures ranging from -65 to +160 degrees fahrenheit with no affect to the unit.

Other tests included a burst test to 12,000 psig, a proof test to 6000 psig, thermal shock from -65 to +160 degrees Fahrenheit, shock and vibration testing per Mil-Std-810C, and a fragmentation test per Mil-C-7905E, which uses an incendiary projectile to fragment the vessel.

The only thermal expansion concern not addressed is that along the length of the vessel. York Aerospace does not believe this to be a problem but we have requested that since they have not built cylinders as long as those proposed for the LTHD that some simple analysis be done to provide a value for the axial stress on the composite overwrap. This stress would be caused by the differential thermal expansion of the steel cylinder and the composite overwrap.

Al/SiC is also a strong contender for the recoil cylinders. See section RM-2.

DAP-2 Comment - Several problems exist in the slide concept configuration. The thin wall honeycomb sandwich

construction is both impact and moisture sensitive. Reference to acceptable aircraft construction does not indicate adequacy for howitzers.

Reply - The questions on the use of honeycomb material are good ones and well founded based upon some of the Air Force experience with it. However it must be realized that most of this experience relates to repair experience on honeycomb structures built ten or more years ago. Honeycomb technology has changed considerably in that time. Honeycomb materials were considered in the phase 1 concept mostly for their ability to offer good mechanical properties and low weight in areas of higher shear stress. FMC will look more closely at alternate core materials for even the high shear stress areas and evaluate whether weight targets can be met with alternate materials. In the event that weight requirements leave honeycomb as an only alternative the following arguments and design procedures will be used to alleviate the review team concerns.

Impact Sensitivity:

On the impact sensitivity of honeycomb three things should be noted. First, it is standard design practice to use honeycomb with a cell size smaller than 3/16 inch in applications where impact resistance is a factor. Experience has shown that this cell size significantly

increases impact resistance as compared to larger sizes. Second, although some of the skin thicknesses shown in work done for phase 1 are indeed quite thin, the work showed that at least structurally the concept was feasible. Increased skin thickness will also contribute greatly to impact resistance. Skin thickness can be increased without increases in weight by evaluating the physical size of some of the structures and optimizing the size, weight, and skin thicknesses.

For example, it has been suggested by the review team that the size of the trails seems too big. Reducing section and increasing skin thickness can reduce weight and improve impact resistance. Efforts such as this to maximize skin thickness within weight limits will be made. Thirdly, it is also possible in critical areas where damage may occur to add impact resistant layers of composite over the relatively fragile graphite/epoxy.

Moisture Absorption:

Moisture absorption of honeycomb structures has been a problem in the past in three areas; corrosion of aluminum honeycomb, water droplets forming in the cells, and difficulty in repair of structures with water in the cells. In the last several years much work has been done in the area of coatings to eliminate corrosion on

aluminum. Aluminum core manufacturers now provide special coatings on the core material which the industry believes will eliminate the corrosion problem. To the extent that aluminum honeycomb is required to meet weight targets FMC will attempt to provide sufficient manufacturer supplied data showing the ability of a particular core product to pass moisture or salt spray corrosion tests.

There is a great deal of discussion within the industry at this time as to how the water gets into the cells and what other negative effects it may have on the structure. Indications are that in many cases the water enters through damaged spots on the skins which should have been repaired or that the moisture was built into the part by lack of proper humidity control during manufacture. There has been no evidence that the moisture has a negative effect on the structure. Permeation of moisture through the skins has been known to happen after prolonged exposure but this too has been minimized by the use of special sealant coatings. FMC commonly uses a coating manufactured by Ram Chemicals. The problem of moisture during repair of honeycomb structures can for the most part be eliminated by proper drying of the part prior to repair.

DAP-3 Comment - Pultruded rails are very risky. The likelihood of premature failure due to matrix cracking at the corners

is high. This is caused by inability of the fibers to reinforce the corners. The concept of making four plates and joining them with preformed corners is inadequate. Filament winding in this area would produce a superior structure. Galvanic corrosion and adhesive selections should be addressed.

Reply - It is agreed that pultruded rails are not the best choice for this design. Metal or metal matrix materials are being evaluated for this component. Preliminary finite element analysis is showing that weight budget can be satisfied using conventional materials.

Corner Connections:

FMC is currently working on a slide design that will be made of either two tape laid pieces, a top and a bottom piece, which will be bonded together at the centerline of the rails, or a continuous tape wound part with appropriate cutouts and wound-in joint reinforcements. Both concepts eliminate the corner connections. This could be a filament wound part in production. The cost implications of making this part from a filament winding will be investigated and reported to ARDEC.

Galvanic Corrosion:

It is true that galvanic corrosion will occur if graphite fibers contact aluminum. In all areas where aluminum is used one of a number of film adhesives will be used which are specially made to electrically insulate the graphite fibers in the composite from the aluminum.

DAP-4 Comment - Honeycomb core construction in the trails is a concern due to impact damage and moisture absorption. Preformed woven corners seem inadequate. Complexity and cost would be high with this concept. The choice of a factor of safety approach is not as adequate as hot/wet property data.

Reply - Impact and Moisture Absorption:

See DAP-2

Corner Connections:

In this particular application FMC felt that a design using four plates connected at the corners is a lower risk approach in terms of cost and schedule as it relates to a single prototype. This construction method has been proven in other applications to be an acceptable method for connection in the presence of shear loads. It is recognized however that it does introduce some weight

penalty and that on a production basis the part would probably be filament wound. FMC is therefore investigating the possibility of tape winding the structure which would be more representative of a filament wound structure.

Factor of Safety Versus Hot/Wet Property Data:

FMC standard procedure is to use nothing but hot/wet property data as material allowables with the traditional factor of safety added on top of this. This was not explained well in the phase I report and we apologize for the omission. Hot/wet data was not used in the Phase I analysis because it was not available at that time. Hot/wet data is included in Appendix C2 and will be used during Phase II.

DAP-5 Comment - The choice of graphite epoxy skin with aluminum honeycomb core in the platform area invites two potential problems. One is the moisture effects on honeycomb construction and two is the shielding of aluminum from graphite to prevent galvanic corrosion. Hand lay-up and autoclave cure is reasonable for these parts.

Reply - Moisture and Corrosion

See DAP-2.

DAP-6 Comment - The "claws" are constructed as described above and similar problems are foreseen. The claw should be designed for damage tolerance since it is expected to interface with the ground. Graphite epoxy skin is inadequate for this purpose.

Reply - Damage Tolerance of the Claws:

It is agreed that the claws must be made more damage tolerant than the graphite epoxy material concept proposed in Phase I. This part will probably be made from aluminum or titanium. A tubular space frame is one contender. FMC is also currently working with Astech Corporation to evaluate designing the claws from a steel corrugated core with steel face sheets. This design can be impact hardened at critical locations with welded-in steel inserts. A sample of this material has been forwarded to Adolph Slobodzinski at ARDEC. Weight/cost/function trade-offs will be evaluated and a recommendation made to ARDEC as part of the regular scheduled design reviews.

DAP-7 Comment - The "backbone" is constructed using a hand lay-up procedure rather than being filament wound. This is considered a poor approach for this component. Removing the

mandrel to form a concave section may result in a wrinkled, void filled structure that will not possess the desired mechanical properties.

Reply - Dolly Backbone Construction:

The dolly backbone has been reconfigured to address this concern as well as to minimize/eliminate pinch points.

DAP-8 Comment - ~~All components should be inspected by ultrasonic techniques.~~ No indication of inspecting for moisture absorption exists. This must be addressed.

per Argento

Reply - Inspection methods will be discussed in the Product Assurance Plan. Inspection methods will be matched to the part design and material selected.

DAP-9 Comment - The bolted joint method of integration is acceptable; however, corrosion and sealing of the holes from moisture should be addressed.

Reply - Sealing of Bolt Holes:

Corrosion in the areas of bolted joints will be addressed the same way as corrosion of aluminum honeycomb. The

aluminum inserts and shims will be anodized and separated from the graphite fibers with a film adhesive. Most holes will not require sealing in that metal bushings will be bonded into the composite holes to distribute contact stresses. Those holes without bushings will either have metal threaded inserts or will be sealed with a resin sealer.

DAP-10 Comment - Bulkiness in trail design is also a concern. It is not clear what weight optimization process ruled out a more reasonable selection of dimensions. The construction does not seem to take damage tolerance and environmental degradation factors into account.

Reply - The trail section depth was chosen to:

1. Maximize resistance to bending (caused by support of at-battery cannon weight), which in turn maximizes system elasticity, thus minimizing propensity to hop at zero QE fire.
2. Spread trail bearings as far apart as possible to reduce bearing loads, which in turn minimizes weight.

3. Facilitate torsionally locking the trail to the upper and lower portions of the platform, serving further to maximize stiffness while minimizing weight.

Smaller forward sections are being evaluated to provide a more damage-tolerant structure which is light weight.

See DAP-2 and DAP-4 for additional discussion on the trail design.

FMC Structural Verification

SV-1 Comment - Beam stress calculations on the supporting trails which allow 70 kpsi in a quasi-isotropic lay-up of graphite epoxy seem suspect. The allowed stress cannot possibly be greater than 50 kpsi for a quasi-isotropic lay-up, even before introducing moisture effect degradation factors.

Reply - Allowable Stresses:

In many cases in phase 1 the starting point for our calculations was to take a reasonable stress value and use the force over area formula to arrive at a starting point for the laminate strain calculations. 50,000 psi was chosen as a reasonable value and this can certainly be argued. However in all cases the report contains at the end of each supplementary section a copy of the computer printout in which a ply by ply analysis was done on the proposed laminate. The trail design is being analyzed using a composites laminate optimizer program. This analysis takes into account the resultant dynamic loads as indicated by the dynamic analysis and the actual published ply-by-ply allowable strains. The allowable ply strains are mathematically transformed to the ply axis. The result is an analysis of first ply failure whether it be axial or

any angled plies. A factor of safety is applied to these results to guarantee that all ply strains are significantly below the failure strains. Again, it is agreed that hot/wet property data should be used for the design allowables and will be in the detailed analysis in phase 2. In addition appropriate knockdown factors for impact resistance will be incorporated.

SV-2 Comment - There is also a disregard for environmental effect, including hot/wet conditions and impact damage degradation effects.

Reply - Environmental Effects:

In phase 2 hot/wet property data will be used for the proposed materials and used as the design allowable. We have determined the proper stacking sequence to give maximum strength for minimum weight for Gr/Ep filament wound trails as discussed in reply to SV-1. Loads are being determined using finite element analysis as part of this design process. Preliminary calculations have shown that maximum stresses seen in any lamina is about 15 KSI which is well within strength limits of the materials used. Calculations have also been run for hot/wet conditions to calculate the stress/deflection levels. This

information will be reviewed with ARDEC at the next scheduled design review or by arrangement with program manager.

Impact Effects:

Damage resistants will be determined from published data or by test to evaluate the effect of impact on the proposed sandwich structures.

SV-3 Comment - The claimed skin thickness in the trail beam of .019" in the sandwich flange is suspect.

Reply - Trail Skin Thickness:

The skin thickness is 0.19" not 0.019" for the Gr/Ep filament wound trails. We have used programs available from the University of Delaware to obtain mechanical property values for hot/wet conditions. Changes in part dimensions, loads, hot/wet material data, and impact criteria requirements will be factored into the analysis and design in Phase II.

SV-4 Comment - The pultruded rail design is suspect. The corners

are vulnerable to cracking when the structure is loaded in bending.

Reply - See DAP-3.

SV-5 Comment - The graphite epoxy skin of the claws appears to be vulnerable. This area should be addressed utilizing a damage tolerant design criteria.

Reply - See DAP-6.

SV-6 Comment - Strength calculations are questionable because of the dry room temperature values used. The knockdown factors are generated from the Tsai-Wu equation; however, the stresses calculated have sketchy rationale. The documentation does not indicate how these stresses are derived.

Reply - See SV-1

SV-7 Comment - No justification has been given for the size of the trails. Collaboration on the design methodology of these components is desired.

Reply - See DAP-10

FMC System Stability

SS-1 Comment - A trapezoidal recoil force profile is most desirable but not always obtainable. Maintaining this profile through 8 and a half feet of recoil travel will be difficult, especially in light of the "energy taps" employed for the hydraulic system. Temperature induced gas pressure changes, as they affect recoil force, appear not to be adequately addressed. A "sensitivity" analysis would be helpful.

Reply - The intent is to determine the "ideal trapezoidal recoil force profile" that has enough margin to permit reasonable deviations in actual practice.

The current margin between ideal and tolerable is 12.8% (see Dynamic Analysis Report pages 20, 22). The primary causes of variations are expected to be from:

1. Calculation variance (predicted versus actual)
2. Impact of temperature upon the nitrogen pressure in the counterrecoil accumulator, the fluid viscosity, and the variations in the components.

3. Variations caused by status of energy recovery system during firing
4. Manufacturing tolerances

Correction of the calculation variance could be one by-product of the demonstrator. Variation due to ambient temperature fluctuations are compensated for as described in the following paragraph. Variations due to the status of the energy recovery accumulator are expected to be roughly 4.5%. Thus, tolerable variations due to manufacturing tolerances must be less than 8.3% to maintain stability. We feel this is realistic.

The nitrogen pressure in the counterrecoil accumulator can be adjusted via the Recoil System Volume Control Valve (recoil system pressure is monitored by the Recoil System Pressure Gauge). Adjusting this pressure as a function of system temperature will facilitate inclusion of viscosity and dimensional variations which result from ambient temperature variations. (This would probably be most easily accomplished via a gauge face calibrated in system temperature rather than pressure, thus eliminating a conversion table in the manual.)

SS-2 Comment - Counter-recoil stability is mentioned but not fully investigated.

Reply - Section 4.2 of the Dynamic Analysis Report presents the analysis to date in this area. As long as the decelerating force during counter-recoil does not exceed 5,000 lbs, no stability problems are anticipated. Initial analysis indicates that counter recoil stability is not a problem. When the counter-recoil force profile is better defined, this concern will be reevaluated and the results presented to ARDEC.

SS-3 Comment - Rifling torque appears not to be included in stability computations.

Reply - Rifling torque computations were performed. Page 38 of the Dynamic Analysis Report reported the results, but no computations were included. The computations are included in Appendix C3. The calculated side hop is .036" (Dynamic Analysis Report reported "not ... more than 0.25 inches").

FMC Cannon/Ammo

CA-1 Comment - Cannon interface was not adequately determined until after Phase I final review.

Reply - We agree. Information was provided to Russ Fiscella and Malcolm Dale from Benet Weapons Lab and Steve Floroff from ARDEC on 13 June 1986 at Benet.

CA-2 Comment - The automatic breech opening mechanism for this design has not been determined.

Reply - We have not provided ARDEC with a drawing of our concept. A concept for a breech opening mechanism was discussed at Benet on 13 June 1986 with above mentioned individuals (CA-1 Reply). Concept was agreed to in principle and details will be provided on the concept interface drawing which will be provided by October 17th to ARDEC.

CA-3 Comment - The primer feed mechanism has not been adequately defined.

Reply - A primer feed mechanism is being developed by FMC for another demonstrator program. The primer inserter mechanism has gone through first generation development prototype testing and is being redesigned based on the results of these prototype test and evaluation results. We are scheduled to have a second prototype available by April 1, 1987. Plans are to fabricate a primer feeder to this design for use on the LTHD program.

FMC Recoil Mechanism

RM-1 Comment - The effects of the external cylinders used for power recovery and storage on the recoil cycle has not been addressed.

Reply - The effects of the external cylinders has been addressed in the System Stability section under the SS-1 reply.

RM-2 Comment - The manufacturing of an effective ten foot recoil mechanism is of great concern.

Reply - The 105 inch max recoil stroke length, of which up to 102 inches will be used under worst-case firing conditions, will be 35 inches longer than the M198 recoil mechanism (which has a 70 inch max stroke). Our Advanced Manufacturing personnel (familiar with the M198 recoil mechanism) do not feel the 105 inch recoil stroke by itself is higher risk than the M198 recoil mechanism. We are considering both composite and metal cylinders. If metal matrix (AL/SiC) material is employed, there would be some risk in developing manufacturing processes, although the

dimensional stability issue (primary problem on M198)
should improve.

RM-3 Comment - A trapezoidal shape recoil force vs. time curve
is utilized for all analyses. A more conservative approach
in which some room is allowed for non-ideal circumstances
is preferred.

Reply - The use of a trapezoidal shaped recoil force curve
has been addressed in the System Stability section under
the SS-1 reply.

FMC Organization

0-1 Comment - There appears to be a reluctance by FMC management to bring forth supporting documentation of their efforts. This position hampers not only the FMC effort, but the program as well by not allowing adequate monitoring of progress made. A change in this area will be most mutually beneficial and desirable.

Reply - FMC has provided ARDEC all contractually required data plus approximately 50% more data than was planned and bid under Phase I contract. FMC has made every effort to cooperate with ARDEC to provide requested data. The problem noted in this comment stems from a contract SOW and DD Form 1423 which does not accurately indicate the data desired by ARDEC. This has caused FMC cost and schedule problems particularly in the last month of Phase I.

FMC will work more closely with ARDEC during Phase II to avoid last minute changes and changes of direction. Every effort will be made to provide ARDEC preliminary information for comment for timely feedback and monitoring of progress.

0-2

Comment - There seems to be a lack of coordination between CEL and Northern Ordnance. It is felt that the FMC composite experience is very limited - perhaps to that associated with the Bradley Fighting Vehicle. The primary emphasis and design philosophy brought forth in the Light Weight Towed Howitzer is that of metal construction. If this philosophy and outlook does not change, grave design errors are likely to occur.

Reply - CEL's involvement in the Phase I effort represented less than 10% of the effort and consisted of: 1) creating a finite element model of the system for structural analysis and 2) towing stability simulation. The selection of the materials required based on detailed analysis is planned for Phase II. The background information which was presented at the June 4th review was not intended to answer the detailed application questions which resulted at that review.

FMC has significant experience in composite parts development and has invested several million dollars in equipping a laboratory to build composite parts. A list of experiences include Bradley turret and turret basket, M113 hull, torpedo dolly and stowage tray, and MK45 weather shield. FMC has engineering personnel with over 20 years of composite design experience with companies including Boeing, Sikorsky, Fiberite and Beach Aircraft. In

addition, qualified vendors are being selected, an example being York Industries for composite hydraulic cylinders.

We understand the need to utilize composites to meet the weight targets. Composite designs are being investigated for the trails, slide, spade assembly and gimbal; heavy parts which offer the greatest potential for weight reduction. Preliminary designs for these parts are being developed and will be ready for review in late September.

0-3 Comment - It is unclear why this effort has both a program manager and project manager. Discussion of this question with Ms. Tia Stackland resulted in a poor explanation.

Reply - FMC's program management organization has consisted of a program manager from the business side of the organization and a project manager from engineering to direct the technical activities on development projects. This was the program management structure shown in the approved program plan for the LTHD program. FMC recognized that at times this was like dealing with a two-tiered management structure and the customer did not understand the relationship or the necessity for both.

Because of comments such as yours, we have made a change to our project team structure. A program manager who has

unilateral authority and is a senior level person has been assigned singular leadership responsibility. A contract administrator is assigned to assist him or her and handle many of the contract issues. The product manager from business development will continue to handle the marketing activities.

0-4 Comment - The entire cannon interface portion of this program was poorly executed.

Reply - This comment refers to the subcontract relationship which was originally proposed for acquiring a cannon assembly from Watervliet Arsenal (WVA). Watervliet had not worked as a subcontractor previously, but had been told that the relationship would be legally acceptable. Upon exploring the matter further, Gerry Cooper from Rock Island Arsenal indicated that the relationship represented a conflict of interest as it relates to the other competing contractors. It was then decided, by the government, that the cannon assembly should be furnished GFE. This area has been a learning experience for both FMC, WVA, RIA, and ARDEC.

0-5 Comment - Program has undergone a shake-up in management midway through Phase I. This is apparent in the organization of this entire program. Numerous significant design changes up to the conclusion of Phase I indicate that personnel are not clear on their direction.

Reply - Every effort was made by FMC management to communicate the reasons for changing product managers in May on this project. The remaining team members were with the program throughout Phase I with the duties proposed in the approved Program Plan. The design changes and changes in direction were the results of FMC's attempts to be responsive to comments from ARDEC, eliminate design deficiencies and provide an acceptable concept. Many of the last minute changes were the result of input at the June 4th review.

Additional reviews and meetings are planned with the customer during Phase II to provide improved feedback and communications with ARDEC and reduce confusion and chaos caused by engineering changes.

See also reply to comment 0-3 relative to Phase II.

0-6 Comment - Technical personnel seem well motivated however, numerous design changes apparent at the final review indicate they also are unclear of their direction.

Reply - The reason for last minute changes is explained above in O-5 and were caused by trade-off analysis and our desire to overcome operational deficiencies identified at the June 4th review.

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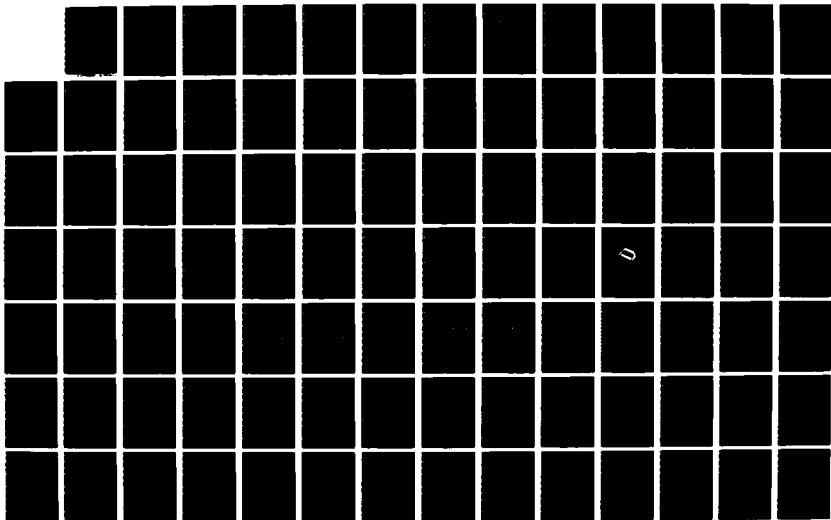
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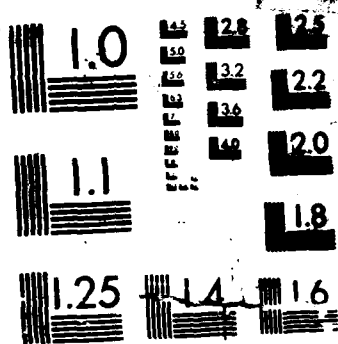
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MICROCOPY RESOLUTION TEST CHART

FMC Quality Assurance

QA-1 Comment - The inspection facilities that FMC has shown are predominantly laboratory testing apparatus. They are able to test coupons and tensile samples, but it is felt that large, full size, howitzer structures are going to pose a problem.

Reply - CEL has tested entire Armored Personnel Carriers in its facilities without any difficulties. Therefore, we do not foresee any problem with testing any large, full size, howitzer structure. A detailed layout of the test facility with a description of capabilities will be provided at the September 5th review.

QA-2 Comment - The honeycomb composite structure used throughout the concept has a moisture absorption characteristic that results in decreased mechanical performance. Because the proposed outside skin is an organic composite it will be very difficult to inspect for moisture content.

Reply - The Gr/Ep-Honeycomb structure proposal represents one possible design approach - not necessarily the final

one to be taken. As part of Phase II analysis work, a number of types of materials will be considered and analyzed before final selection is made.

The honeycombed structure was proposed because of its high strength/weight ratio. Material properties used will reflect worst case moisture absorption physical constant test information. See also significant discussion on this topic in the Design Adequacy and Producibility Section.

QA-3 Comment - FMC has given little consideration to producibility aspects - the hand lay-up techniques proposed are very expensive.

Reply - We will use the most cost effective method to produce the demonstrator parts. This will not always mean, that multiple part fabrication would be achieved using the same method. We will, whenever feasible within budget and schedule, include details about different fabrication techniques we would recommend to be used in multiple fabrication. Cost trade-offs will be presented to ARDEC as part of the design review process and they will have input to the manufacturing process selected for prototype parts.

QA-4 Comment - The loader feeder for primers is a complicated unproven device - this can be a major RAM problem.

Reply - We share the concern and are monitoring closely in-house progress as well as progress with primer feeder mechanisms by others in order to provide a reliable component. A primer feed mechanism is being developed by FMC as discussed in the CA-3 reply.

QA-5 Comment - The cantilevering of the gun may cause fire control problems because of vibrational modes and/or instabilities.

Reply - The entire LTHD system is set up as a finite element model. Alternate materials will be investigated to insure that structure is not excitable at a natural frequency with resulting instability. If preliminary analysis indicates problems, a more detailed modal analysis can be performed.

QA-6 Comment - The skin of the so called "claws" is proposed to be graphite epoxy. It is hard to foresee this construction surviving the type of abuse it will receive.

Reply - We agree. If the claw must be able to withstand hitting by a sledge hammer, a metal material such as aluminum or titanium would be much more damage tolerant. We will include this concern as one of the design

requirements for the claw in Phase II and determine the weight trade-off.

QA-7 Comment - The equilibration cables seem to be a potential RAM problem.

Reply - The equilibration cable design and the RAM implications are discussed in detail in Appendix C-1. The cables are designed to provide redundancy where one cable will support the entire load with a generous safety factor of 8 for maximum static loads. Our analysis shows that the load on the cable never goes to zero. Normal working loads are under 10% of the breaking strength. Cables have been designed as recommended in the design guides and redundancy will provide a safety factor. They are utilized because of their light weight for tension loading applications.

QA-8 Comment - The P.A. plan is scarcely addressed.

Reply - A draft Preliminary Nondestructive Testing and Product Assurance List developed under C.2.C.1.d of the SOW was submitted for review to Mr. Joseph Argento (AMSMC-QAH-T) on 29 May, 1986 (cc. Norm Lionetti, SMCAR-FSA-F). We believed that it satisfied our submission requirement for Phase I. We interpreted C.2.C.2.e as required to be developed in Phase II. The product

assurance plan is presently under development and our goal is to review draft plan with Mr. Argento by the middle of September.

QA-9 Comment - It appears that little consideration has been given to the formulation of an impact damage assessment.

Reply - We agree. Damage criteria were not established in the first phase and the primary effort was focused on meeting the weight criteria and satisfying operational requirements. We did not cost significant effort in this area in our proposal and we are assessing the impact on program cost. Materials selected will be evaluated for damage resistance during Phase II with the damage criteria established through agreement with ARDEC. An impact damage assessment for mission critical composite parts will be part of our preliminary product assurance plan.

QA-10 Comment - There is no indication of any thought given to the delamination problem which may occur from expansion between over wrapped cylinders and the composite wrapping.

Reply - This comment raises similar issues to that raised previously under DAP-1. See DAP-1 for answer.

QA-11 Comment - The recoil slides/cradle is viewed as having three serious potential problems:

1. Degradation by moisture absorption.
2. The method utilized for joining the four sides appears very similar to ones used for metal fabrication. This structure would seem to be much more efficient if filament wound.
3. In the chosen configuration, the glass or graphite pultrusions that are to make up the slides seem very prone to develop cracks due to a lack of reinforcement inherent in the pultrusion process. In addition, residual stresses in the material due to resin shrinkage may be enough to initiate cracks.

Reply - This comment raises similar issues to those raised previously. See DAP-2, 3 and 4 for the answer to this comment.

SLIDE

APPENDIX

FROM	TO	DRIVE	SCHEMATIC
RESA	X	X	X
STORAGE	X	X	X

PUMP INLET/OUTLET

This Appendix is prepared to provide a framework for the explanation of the questions relative to FMC LTHD Operations. Accordingly, the following sections support this end.

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Recoil System Volume.....	A1-2
Recoil Position.....	A1-3
Recoil Position.....	A1-3
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Supporting Analysis and Data.....	C
Reliability Analysis of Equilibration Cables.....	C1
Hot-Wet Data for AS4/3501.....	C2
Rifling Torque - Stability Computations.....	C3

ADD TEMP GAGE

SOFT IN VALVES
RECOIL
EQUILIB
MA

1 VALVE?
W/ INTERLOCKS

MANUAL PRIMER
REPLACEMENT

1 VALVE?

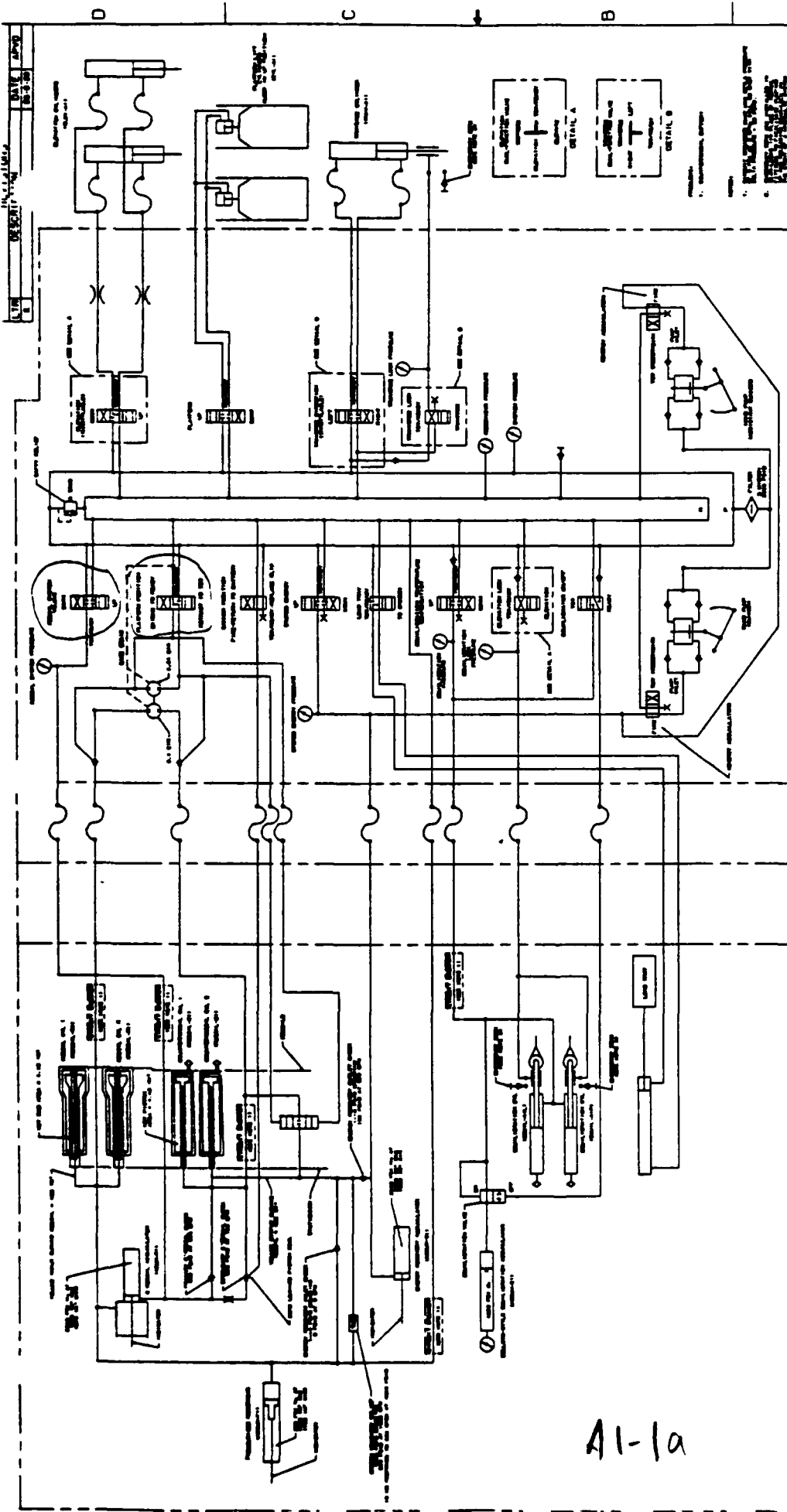
SLIDE 5 - 3 - 3
PUMP - 4 - 3
CO - 2 - 1
AG - 1 - 1

Note 1: Descriptions assumes that the hydraulic system has sufficient energy storage. The procedures required if this is not the case are covered under the Hand Pump Sections (A1-4 and A1-6).

SECOND EQUATION VALVE

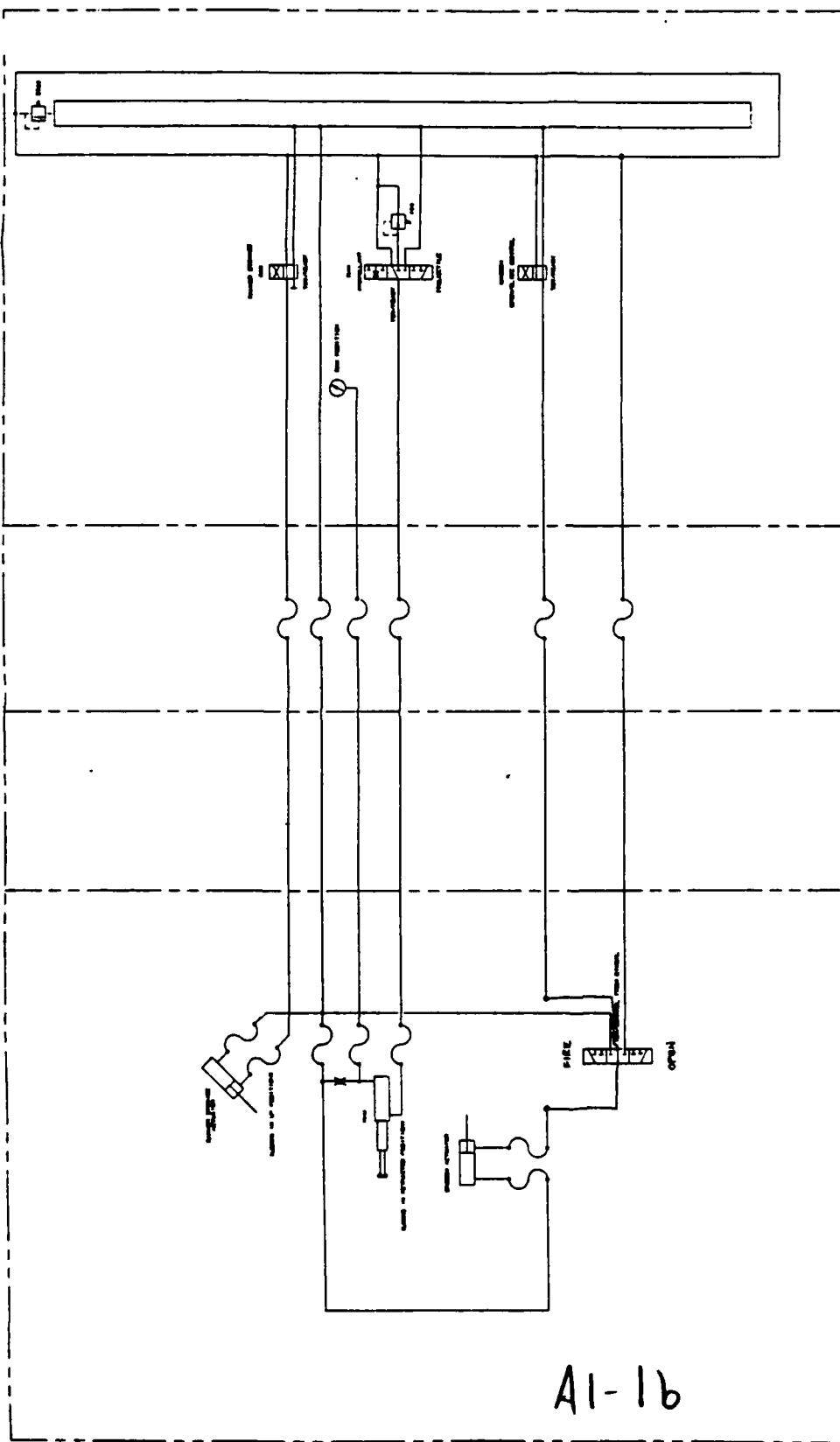
LOADING SYSTEM LOCKOUT

3 4 2 4 4+2



A1-1a

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A1-16

FMC FMC Corporation, Building 10000 Highway 100, Minneapolis, Minnesota 55412	
HYDRAULIC FUNCTIONAL	
DATE 4-11-74	FILE NO. 44114
PART NO. 44114	SHEET 2 OF 2

GIMBAL CONTROLS TO MID-SLIDE MANIFOLD

APPENDIX A1

Narrative

Gunner's Controls. These controls are mounted on the left side of the gimbal and move with the gun in traverse. The gunner can operate the hydraulic controls while looking into the eyepiece of the panoramic scope.

Traverse. This is a "T-pattern" dual function control valve.

Tow/Ready. The traverse system is locked.

Traverse. Moving the handle upward (against a vertical spring) releases the BearLocs (the Traverse Lock Pressure Gage indicates when the lock releases).

Traverse-Left. Moving handle to the right (against a horizontal spring) traverses the gun to the left.

Traverse-Right. Moving handle to the left (against a horizontal spring) traverses the gun to the right.

Cannon Position. Allows the gun to be caught in recoil for replacement of primer clip.

Tow/Ready - Replace Clip. The gun position will be held. During firing this position is used to "catch" the gun to facilitate reloading the auto primer clip (every eight rounds). During displacement, this control will hold the gun in tow position until the travel locks are secure.

Ready - Return to Battery. Moving the handle upward against a spring will return the gun to battery after the recoil cycle.

Recoil System Volume. Recoil System Volume is measured by the Recoil System Pressure Gage and the position of the Recoil Accumulator Indicator (protruding from the Slide Manifold at the forward end of the Slide).

Tow/Ready. The Recoil System is locked up and separated from the Hydraulic System.

Up. Pushing the valve to the right against a spring will add oil to the Recoil System.

Down. If too much oil is accidentally added, the valve can be moved to the left (against another spring) to bleed off some of the excess oil (back into the Hydraulic System).

Platform Position. Extends and retracts the platform during emplacement and displacement, as well facilitates removal of stuck projectiles.

Tow/Ready. The recoil and counterrecoil cylinder volumes are "locked" (unless the "Cannon Position Control" is being held in the "Ready" position, in which case the gun will go to the battery position).

Retract to Tow. To pull gun back into the slide for towing, the Gunner must push the control valve handle down (against a spring) to the the "Retract to Tow" position. Oil is transferred from the Counterrecoil and Energy Recovery Cylinders to the the Recoil Cylinders (volumes are equal) by a closed loop motor-pump.

Extend to Fire. To extend the gun to the firing position, the Gunner must push the control valve handle up (against a spring) to the "Extend to Fire" position. Oil is transferred from the Recoil Cylinders to the Counterrecoil and Energy Recovery Cylinders.

This control can also be used to extract a stuck projectile. The gun is first slightly retracted toward the tow position. Then the pole is set in the bore against the ogive. The strap winch is run around the end of the pole and attached to the forward trail locks. Extending the gun to the firing position facilitates the application of up to 3,500 lbf extraction force. The relative force is monitored by the System Pressure Gage.

Stored Energy. Facilitates manually adding energy to the Energy Accumulator. The magnitude of energy on tap is indicated by the Stored Energy Pressure Gage.

Tow/Ready. In this position, the Energy Accumulator inlet port is connected only to the Energy Recovery Cylinder (manual addition of energy is locked out).

Up. Moving the handle upward against a spring, with the Pump Inlet Control in the Tow (Reservoir Input) position, energy can be added to the Energy Accumulator with the Hand Pump.

Down. Moving the handle downward against a spring, energy can be bled from the Energy Accumulator (to facilitate servicing the Energy Accumulator).

Pump Inlet. A heavily detented two position control valve that selects the inlet to the hand pump from the Pressurized Reservoir or the Energy Recovery Accumulator.

Tow (Reservoir). The valve should be left in this position during tow operations to ensure that inadvertent operation of valves do not produce unplanned events. Also used when manually pumping up Energy Accumulator (see Hand Pump Section).

Ready (Energy Accumulator). Normally during firing, energy will be supplied by the Energy Accumulator. Oil will automatically flow from the Pressurized Reservoir in the event that the Energy Accumulator's supply goes to zero.

Hand Pump. Balanced area, double-acting, lever-actuated hand pump.

When a control valve is opened (depleting the pressure header of oil), additional oil will flow through this pump (when the Pump Inlet Control is set to Ready).

If the pressure from the Energy Accumulator is insufficient to achieve the desired effect, additional pressure can be added by pumping the handle of the hand Pump.

To manually recharge the Energy Accumulator, set the Pump Inlet Control to Tow (Reservoir Input), set the Stored Energy Control to Up, and pump one or both the Hand Pump(s). As energy is added to the Energy Recovery Accumulator, the Stored Energy Pressure Gage will so indicate.

Assistant Gunner's Controls. These controls are mounted on the right side of the gimbal and move with the gun in traverse. The Assistant Gunner can operate the hydraulic controls while looking into the eyepiece of the direct fire scope.

Elevation. This is "T-pattern" (laid down) dual function control valve that operates two Elevation Cylinders. The Equilibration Cylinders must be unlocked before the gun can be elevated.

Tow/Ready. The elevation system is locked.

Elevation. Moving the handle to the left (against a horizontal spring) releases the BearLocs (the Elevation Lock Pressure Gage indicates when the lock releases).

Up. Moving handle downward (against a vertical spring) elevates the gun.

Down. Moving handle upward (against a vertical spring) depresses the gun.

Equilibrator Temperature Compensation. This valve is used to adjust the equilibrators for changes in ambient temperature. The Equilibration Pressure Gage monitors the equilibration pressure as it changes with ambient temperature.

Tow/Ready. The Equilibration System is locked.

Up. Moving the handle upward against a spring adds oil to the Equilibration System, thus increasing equilibration (necessary when ambient temperature drops).

Down. Moving the handle downward against a spring removes oil, thus decreasing equilibration (necessary when ambient temperature rises).

Equilibrator On/Off. This is a heavily detented two position control valve that turns the equilibrators on and off.

Tow. Turns the equilibrators off to facilitate lifting the trails off the ground (when the gun is on the dolly) for towing.

Ready. Turns the equilibrators on to elevate the barrel.

Platform. Used to lift the Platform and in turn lift the main spade out of the ground.

Tow/Ready. In this position, the Platform Lift Cylinders are locked in the up position.

Up. Moving the valve handle upward against a spring will extend the Platform Lift Cylinders and Raise the Platform (and spade) out of the ground.

Down. Moving the valve handle downward against a spring will retract the Platform Lift Cylinders and Lower the Platform (and spade) into the ground.

Pump Inlet. Identical to one on Gunner's side. Heavily detented two position control valve that selects the inlet to the hand pump from the Pressurized Reservoir or the Energy Recovery Accumulator.

Tow (Reservoir Input). The valve should be left in this position during tow operations to ensure that inadvertent operation of valves produce no unplanned events. Also used when pumping up manually pumping up Energy Accumulator (see Hand Pump Section).

Ready (Energy Accumulator). Normally during firing, energy will be supplied by the Energy Accumulator. Oil will automatically flow from the Pressurized Reservoir in the event that the Energy Accumulator's supply goes to zero.

Hand Pump. Identical to one on Gunner's side. Balanced area, double-acting, lever-actuated hand pump.

When a control valve is opened (depleting the pressure header of oil), additional oil will flow through this pump (when the Pump Inlet Control is set to Ready).

If the pressure from the Energy Accumulator is insufficient to achieve the desired effect, additional pressure can be added by pumping the handle of the Hand Pump.

To manually recharge the Energy Accumulator, set the Pump Inlet Control to Tow (Reservoir Input), set the Stored Energy Control to Up, and pump one or both the Hand Pump(s). As energy is added to the Energy Recovery Accumulator, the Stored Energy Pressure Gage will so indicate.

Cannoneer 1's Controls. These controls are mounted on the top of the gimbal (except the lanyard, which is mounted on the right inside wall) and move with the gun in traverse. Cannoneer 1 can operate the hydraulic controls while watching all loading operations. Cannoneer 1 can also see if the bore is clear up to 150 mils, if the bag is in position, and if the breech marks are aligned.

Breech. This heavily detented valve hydraulically opens and closes the breech. The breech can only be opened hydraulically when at battery. At any other position it must be opened with the manual handle provided with the basic issue items.

The breech can also be controlled from just behind the breech, inside the slide, and in front of the Rammer (see Mid-Slide Controls section).

Tow/Ready. In this position, the breech is closed.

Open/Control from Slide. Pushing the valve upward opens the breech. This is also the position the valve should be in if the breech is to be opened and closed from the Mid-Slide Controls location.

Should this control be accidentally moved to the Tow/Ready position while the breech is being controlled from the Mid-Slide Controls location, the breech will not close as long as the Mid-Slide Control for the Breech is in the Open position.

Load Tray. Advances and retracts the load tray.

Tow/Ready. The load tray is fully rearward.

To Breech. Raising the valve to this position (against a spring) advances the load tray to the breech face. A mechanical lockout must first be released (to eliminate the possibility of accidentally advancing the Load Tray when the cannoneer is behind the breech (see Continuous Firing Procedure Option, Section B3).

In doing so, the brush on the forward part of the load tray passes under the mushroom, cleaning its rearward face.

There is also a pad on the load tray pilot into the breech that cleans the gas check seat.

When the control lever is released, the load tray is retracted. As the load tray retracts, the brush cleans the forward face of the mushroom.

Rammer Stowage. Moves the Rammer from stow to ram position and back.

Tow/Ready. The ramming cylinder is in the up (stow) position.

Load. Pushing downward on the lever (against a spring) positions the Rammer on the centerline of the chamber (Load Tray must be in the Breech position first).

Ram. Two stage cylinder. Both stages are energized to ram the projectile. Reduced pressure is used to extend only one stage, which positions the propellant. The Ram Position Gage indicates when the ram-projectile and position-propellant stages are complete.

The forward end of the Ramming Cylinder Rod has a rearward facing "bristle brush" that brushes the inside diameter (and down into the Swiss notch) of the combustion chamber when the projectile is being rammed and again when the ram is retracting.

Tow/Ready. The Ramming Cylinder is fully retracted.

Projectile. By moving a "safety gate" to the side and pushing the valve upward against a spring, the Ramming Cylinder extends both stages and rams the projectile.

Propellant. Pushing the valve lever downward against a spring, the Ramming Cylinder extends only one stage, and positions the propellant a nominal 0.25 inches beyond the Swiss notch.

Lanyard. This manually pulled 13 foot cable is attached on the inside of the gimbal at a height of about 3 feet. It is routed (through an eyelet on the underside of the Ramming Cylinder mount) and semi-permanently attached to the auto primer.

Mid-Slide Controls.

Breech. This heavily detented valve hydraulically opens and closes the breech. The breech can be opened hydraulically only when at battery. At any other position it must be opened with the manual handle provided with the basic issue items.

The breech can also be controlled from behind the gimbal (see Cannoneer 1's Controls section).

Tow/Control from Gimbal. In this position, the breech is closed. This is also the position the valve should be in if the breech is to be opened and closed from the gimbal.

Open. Pushing the valve upward opens the breech.

Should Cannoneer 1's Control for the Breech be accidentally moved to the Tow/Ready position while the breech is being controlled from the Mid-Slide Controls location, the breech will not close as long as the control lever is in this position.

Ready. Pushing the valve lever downward closes the breech.

Recoil System. The Recoil System is part of the Hydraulic System. As a result, the Recoil System can be monitored and replenished with oil as required by the Gunner. However, the Recoil System has hydraulic circuit breakers that protect it from loss of oil, should a major rupture occur elsewhere in the Hydraulic System.

The recoil stroke can be fine tuned by adjusting the pressure in the high pressure side of the counterrecoil accumulator. The Recoil System Volume Control would provide the adjustment means, the Recoil System Pressure Gauge provides the measure.

Recoil Cylinders. Two identical recoil cylinders are mounted on either side of the cannon. Cavitation is minimized by connection to the Pressurized (to 200 psi) Reservoir.

Counterrecoil Cylinders. One is traditional (fed by a counterrecoil accumulator). The other is fed by the pressurized reservoir, and thus supplies minimal return-to-battery force. But on recoil, the oil from this second cylinder is diverted into the Energy Recovery Accumulator. As the first cylinder returns the gun to the battery position, the second is recharged with oil from the Pressurized Reservoir, in preparation for another recoil cycle.

Counterrecoil Accumulator. Self-displacing 2:1 (low:high pressure) provides counterrecoil pressure while minimizing cavitation in the Recoil Cylinders during recoil.

Counterrecoil Buffer. Twelve inch stroke shock absorber with profiled resistance to bring cannon to minimal velocity during counterrecoil.

Energy Recovery Accumulator. When the Energy Recovery Accumulator is full, additional fluid is bypassed to the Pressurized Reservoir via the Energy Recovery Relief Valve.

If the Energy Recovery Relief Valve fails, the nitrogen in the Energy Recovery Accumulator would go to roughly 6000 psi. The Stored Energy Pressure Gauge would indicate an excess of Stored Energy, and the Safety Relief would bleed off the excess energy (back to the A1-10 Pressurized Reservoir) at a rate suitable for the maximum rate of fire.

Pressurized Reservoir. Serves as a source of oil for the Energy Recovery Accumulator in preparation of a recoil cycle, and as a general source of fluid to the total Hydraulic System.

Equilibration System. The Equilibration System is part of the Hydraulic System. As a result, it can be monitored and replenished with oil as required by the Assistant Gunner. However, the Equilibration System has a hydraulic circuit breaker that protects it from loss of oil, should a major rupture occur elsewhere in the Hydraulic System.

In order to elevate manually (strap winch at the elevation cylinders), the BearLocs must be disabled by removing the BearLoc fittings and installing the grease zerks mounted next to them, and pressurizing with a grease gun.

Load Tray.

The Load Tray is loaded with the propellant and projectile as follows (procedure is for maximum rate of fire).

The propellant is slid into the propellant tube, and the tube is pushed over (to the left, against a spring) to make room for the projectile. The propellant tube is slightly larger than the M203 and is hinged at the bottom.

While holding the propellant tube to the left (against its spring) the projectile is slid into the load tray. Once in place, the projectile holds the propellant tube in position.

Once the load tray is advanced to the breech, the rammer is swiveled down to a position directly behind the base of the projectile.

As the projectile is rammed, disks on the side of the rammer rod hold the propellant tube in position (in the absence of the projectile).

When the rammer is fully retracted to behind the face of the propellant tube, the propellant tube is swiveled in front of the rammer by the propellant tube spring.

At that time, the rammer is energized (at a lower pressure - low enough to extend only one stage of the rammer) and the contents of the propellant tube enter the chamber. The gaps between the end-of-the-propellant-tube and the pilot-into-the-breech (on the load tray) as well as the gap between the pilot-into-the-breech and the breech-face are well under 1 inch with smooth transitions, to eliminate snags.

When the rammer bottoms, the propellant will be just beyond the Swiss notch, at which time the rammer is retracted.

The rammer is swiveled up, the load tray is retracted, the breech is closed, and the gun is ready to fire.

The procedure for the continuous rate of fire option is identical except the propellant is manually inserted by the cannoneer positioned near the breech.

APPENDIX B OPERATING PROCEDURES

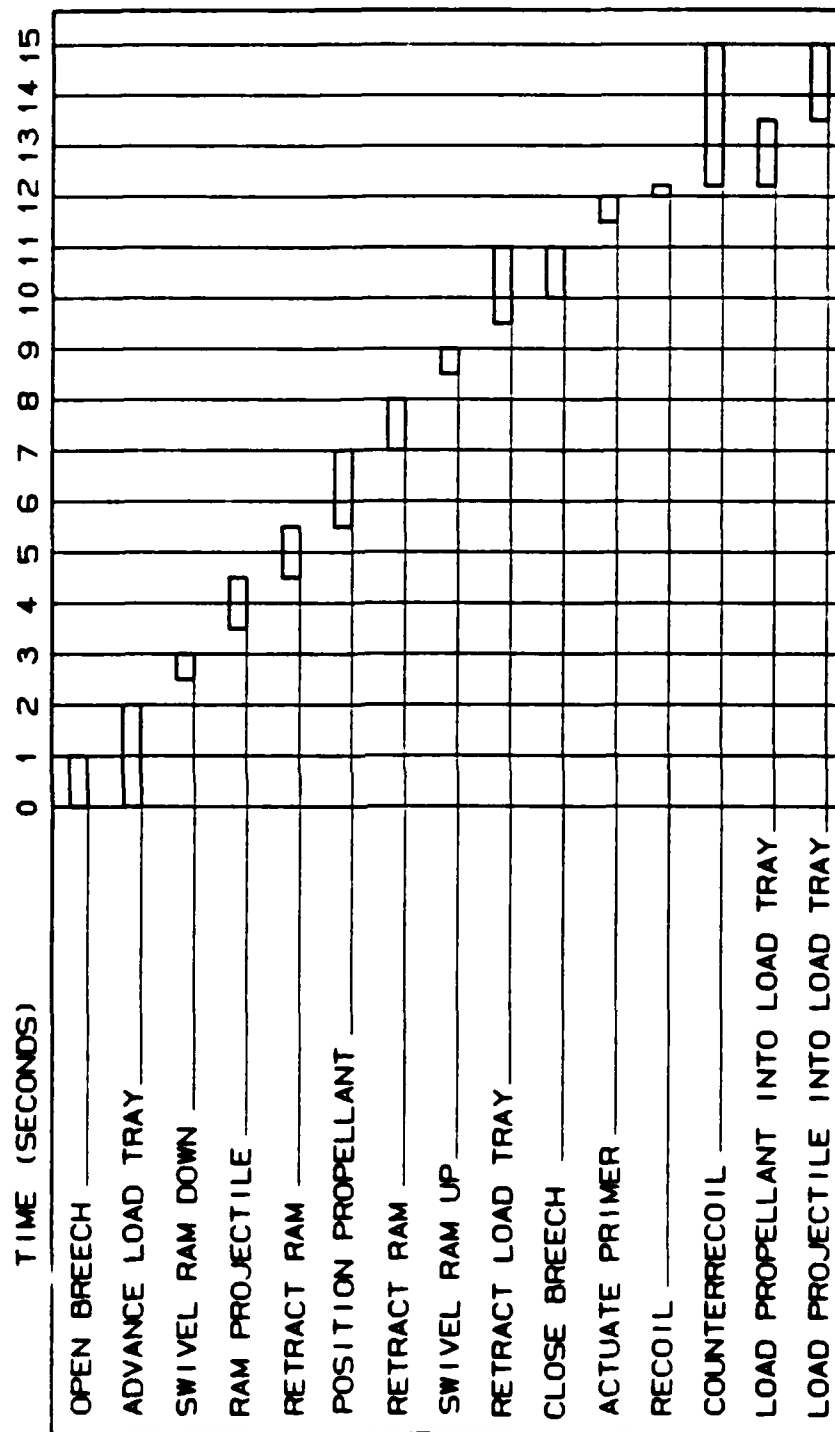
Disconnection from truck and emplacement

Step.....	Valve.....	Valve Position
Set manual brakes.....	.....	.....
Disconnect electrical from truck...	.....	.....
Release air lines from truck.....	.....	.....
Release air lines (slide to dolly) .....	.....	.....
Release out-of-battery latch.....	.....	.....
Extend platform.....	Platform Position..	Extend to Fire
5 Set lunette on ground.....	.....	.....
1 Unlatch claws.....	.....	.....
6 Swivel claws down.....	.....	.....
2 Unlatch trail pivot locks.....	.....	.....
3 Spread trails.....	.....	.....
4 Latch trail pivot locks.....	.....	.....
7 Set trails on ground.....	Elevation.....	Up.....
Turn on equilibrators.....	Equilibrator On/Off	On.....
Elevate gun.....	Elevation.....	Up.....
Remove dolly.....	.....	.....
Lift platform (to dig in spade)....	Platform.....	Up.....
Dig in spade (if penetration under 6") .....	.....	.....
Lay weapon.....	.....	.....
Load auto primer clip.....	.....	.....

Go to firing procedure.

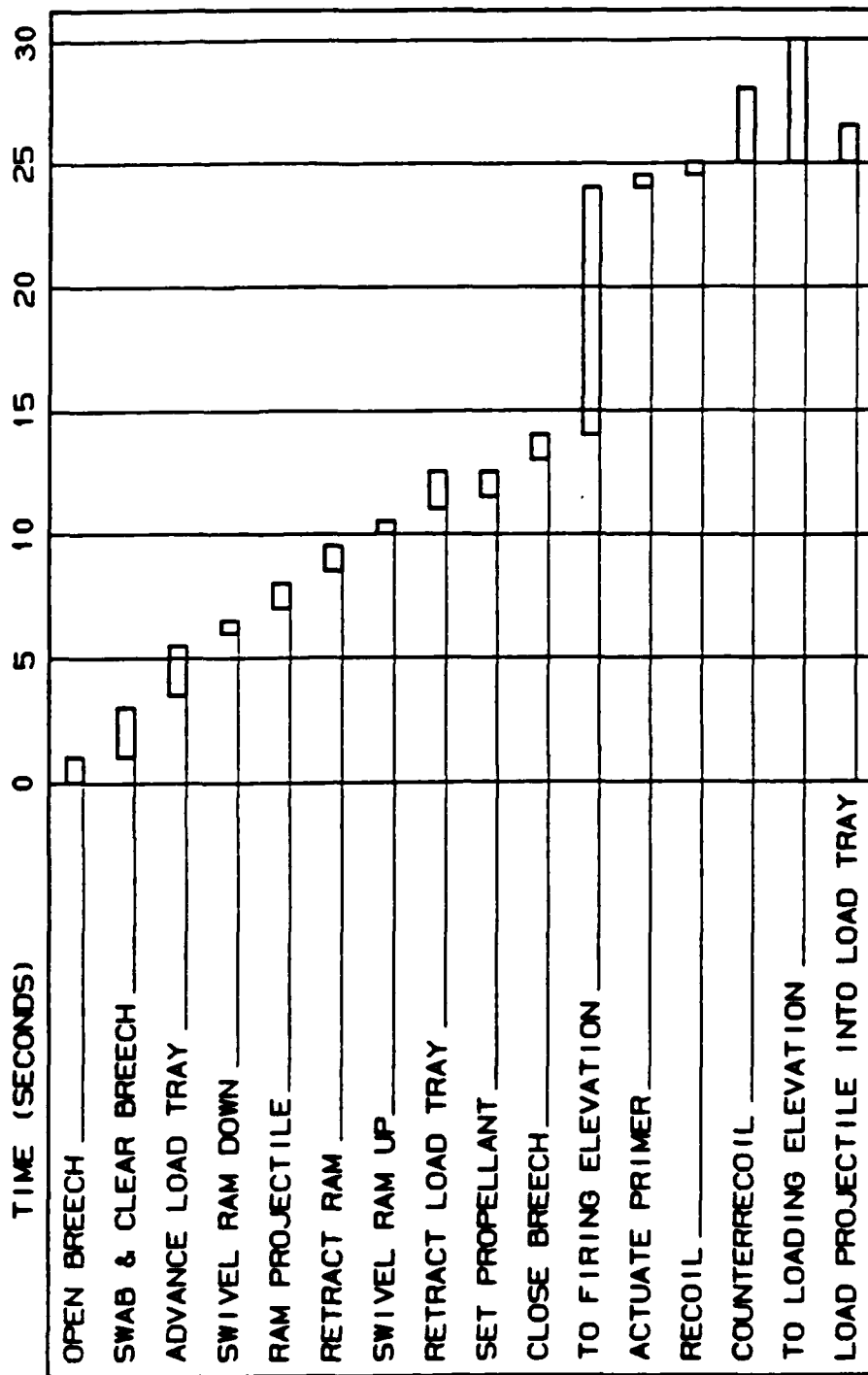
APPENDIX B2

MAXIMUM RATE OF FIRE PROCEDURE (FOUR ROUNDS PER MINUTE)

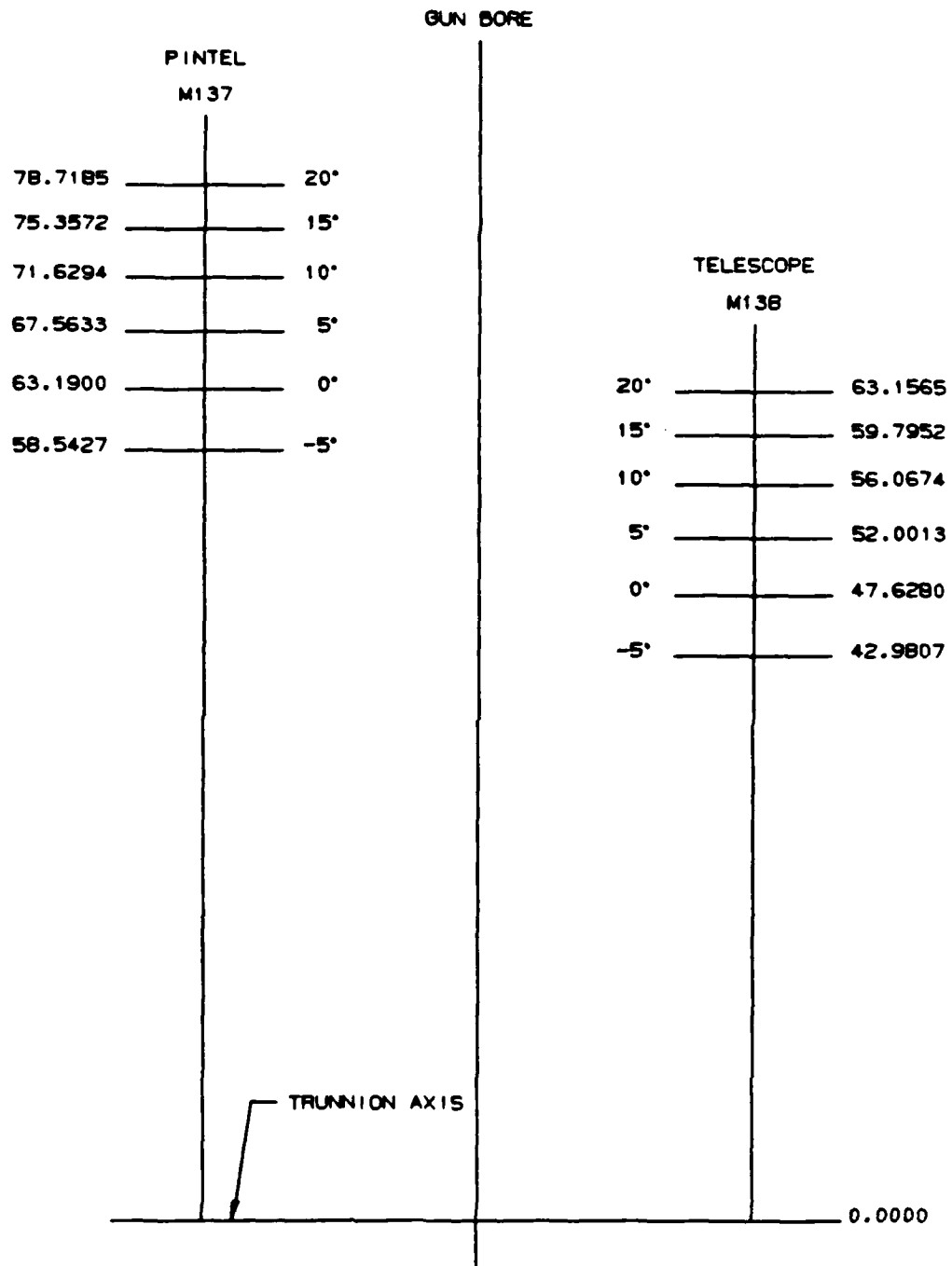


APPENDIX B3

CONTINUOUS RATE OF FIRE PROCEDURE OPTION (TWO ROUNDS PER MINUTE)



APPENDIX B4



APPENDIX C

SUPPORTING ANALYSIS AND DATA

Appendix C1 - Reliability Analysis of Equilibration Cables

1. System Description

Two pre-tensioned Kevlar-29 cables 11 feet long connect the LTHD equilibration cylinders to the upper platform. The cables have a continuous torque-balanced weave with loops at both ends which are permanently wrapped around 5.5 inch diameter pulleys. The cable diameter at the pulleys is 1.28 inches, the cable diameter between pulleys is 1.64 inches. The pulleys at the equilibration cylinder end do not rotate; the pulleys attached to the upper platform are able to rotate.

2. Static Loading

The maximum static load on the cables occurs when the recoil mass is in battery position. Maximum static load values per cable are 17,230 lbs for 0 degrees elevation and 14,880 lbs for 72 degrees elevation. The break strength of each cable is 275,680 lbs. Thus, a safety factor of 16:1 is provided for maximum static loads. If the LTHD is fired in a degraded condition with one cable, the safety factor is reduced to 8:1. Dynamic loads are discussed in the following paragraphs.

3. Dynamic Loading

The cable materials' flexibility allows it to withstand dynamic loading, including impact loading. Dynamic loading conditions include: changing gun elevation prior to firing; and during firing, which includes the impact from the rifling torque imparted to the slide assembly (which in turn, is partially imparted to the cables), and the change in cable tension resulting from a shift in supported weight CG.

As the CG of the supported weight shifts due to recoil, preliminary dynamic analysis had shown that the cable tension was reduced to a minimum of 7,008 lbs for 0 degree QE firing and 4,840 lbs for 72 degree QE firing. Thus, the cable tension is never zero. The complete dynamic analysis is shown in Appendix X of the Supplementary Information to the Dynamic Analysis Report.

A slight change in cable tension will also occur as a result of rifling torque. The barrel will impart a torque to the slide assembly. The reduced torque which reaches the equilibration cylinders will be countered by the equilibration system cables. The tension in one cable will increase slightly, the other will decrease slightly. The amount of change in cable tension will depend on the stiffness of the slide assembly.

4. Acceptance Requirements/Material Properties

Acceptability requirements for Kevlar parachute cables (rated up to 10,000 lbs/cable) are covered by MIL-C-87129A. Since Kevlar is ultra-violet sensitive, a cable covering is required. The LTHD cables will have braided nylon jackets, which can be dyed to any color. The strength of Kevlar is not affected by contact with hydraulic oils or gasoline. Contact with sea water for 12 months results in a strength decrease of 1.5%.

5. Failure Modes

The Kevlar cables will elongate noticeably before snapping. Ultimate elongation is 3.8 to 4% of length. Should a cable snap, the Kevlar material has low snap-back properties. The most probable location for failure would be where the cable is in contact with the pulleys. To minimize failure, a pulley diameter to cable diameter ratio of 3 to 4 is recommended in the literature. The 5.125 inch pulleys provide a ratio of 4.0.

6. Preventive Maintenance

Preventive maintenance would include visual inspection for cable deterioration. For all areas, flatness, holes and cuts can be found by visually inspecting the protective nylon covering. If there is a significant increase in cable length (up to 4%), replacement will be needed.

7. Fatigue/Durability

When normal working loads are under 10% of the cable break strength, the cables are rated to last 1,000,000 cycles and when working loads are under 20%, the rated life is 100,000 cycles. A general Kevlar fatigue curve states that cable life will be 18,000 cycles (the design life) when the working loads are 29% of the break strength. (Design life is defined as 15,000 rounds fired plus 3,000 emplacement/displacements.) Static loads for the LTHD cables are at 6.25% of break strength and dynamic loads are not expected to be significantly higher. Thus, if a stress concentration factor of 2.0 at the pulleys is assumed, the safety factor (for fatigue, with stress concentration included) over the cable life will always be at least $29/(2*6.25)$ or 2.32.

APPENDIX C2

MAGNAMITE®

AS4/3501-6

**GRAPHITE PREPREG TAPE
AND FABRIC MODULE**

JULY 1985



AEROSPACE PRODUCTS GROUP
Bacchus Works • Magna, Utah 84044

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**PHYSICAL
CHARACTERIZATION**

PREPREG TAPE

TAPE DESCRIPTION

Magnamite® AS4/3501-6 graphite prepreg tape is an amine-cured epoxy resin reinforced with unidirectional graphite fibers. Hercules 3501-6 resin was developed to operate in temperature environments up to 350°F (177°C).

REINFORCEMENT

Hercules Magnamite continuous, type AS4 (high strength), pan-based graphite fiber. The fiber has been surface treated to increase composite interlaminar shear and transverse tensile strength. The surface treatment is not a coating or sizing and does not leave any residue.

RESIN

Hercules 3501-6 (350°F) epoxy resin system consists of:

Base epoxy: Tetraglycidyl Methylene Dianiline (TGMDA)

Curative: BIS (p-aminophenyl) Sufone (DDS)

Catalyst: Boron Trifluoride Lewis Salt

TAPE CHARACTERISTICS

	English Units	Metric Units
Fiber areal weight, graphite only ^a	4.3 oz/yd ²	145 g/cm ²
Standard width ^a	12 in.	30.5 cm
Approximate yield	18.8 ft/lb	12.6 m/kg
Standard resin content, % by wt ^a	35 (± 3)	35 (± 3)
Gel time at 350°F (177°C)	6-12 minutes	6-12 minutes
Volatile content, % by wt	1 maximum	1 maximum
Out time at room temperature	10 days minimum	10 days minimum
Shelf life at 0°F (-18°C)	12 months	12 months
Approximate cured-ply thickness (62% F _v , A.W. = 145 g/m ²)	5.2 mils	0.13 mm
Neat resin density	0.0457 lb/in ³	1.265 g/cm ³
^a . Other widths, fiber weights, and resin contents available upon request.		

PREPREG FABRIC

FABRIC DESCRIPTION

Magnamite prepreg fabrics are a balanced weave of AS4 high-strength fiber impregnated with Hercules 3501-6 epoxy resin. Hercules 3501 is an amine-cured resin, developed to operate in temperature environments up to 350°F (177°C). The fabric has essentially balanced properties in both warp and fill directions, with warp properties typically slightly higher. A Kevlar tracer thread can be inserted in the weave for ease of determining fabric alignment.

FABRIC CHARACTERISTICS

Prepreg Designation	A193-P/3501-6	A370-5H/3501-6	A370-8H/3501-6
FABRIC ONLY			
Fabric style	A193-P	A370-5H	A370-8H
Fabric weave	Plain	5-harness satin	8-harness satin
Fiber areal wt	193 g/m ² (5.7 oz/yd ²)	370 g/m ² (10.9 oz/yd ²)	370 g/m ² (10.9 oz/yd ²)
Construction, warp x fill	4.5 x 4.5 ± 0.2 yarns/cm (11.5 x 11.5 ± 0.5 yarns/in)	4.3 x 4.3 ± 0.2 yarns/cm (11 x 11 ± 0.5 yarns/in)	8.5 x 8.5 ± 0.4 yarns/cm (21.5 x 21.5 ± 1.0 yarns/in)
Yarn filament count	3000	6000	3000
PREPREG FABRIC			
Nominal cured-ply thickness (62% FV)	0.18 mm (7.0 mil)	0.34 mm (13.5 mil)	0.34 mm (13.5 mil)
Standard width	107 cm (42 in.)	99 cm (39 in.)	124 cm (49 in.)
Approx fabric yield (35% resin content)	3.37 m ² /kg (1.83 yd ² /lb)	1.76 m ² /kg (0.95 yd ² /lb)	1.76 m ² /kg (0.95 yd ² /lb)
Resin content, % by wt ^a	32-42 (± 3)	32-42 (± 3)	32-42 (± 3)
Gel time at 350°F (177°C)	6-12 minutes	6-12 minutes	6-12 minutes
Volatiles, % by wt	1.5 maximum	1.5 maximum	1.5 maximum
Out time at room temp	10 days minimum	10 days minimum	10 days minimum
Shelf life at 0°F (-18°C)	12 months	12 months	12 months
^a Other resin contents available upon request			

MECHANICAL PROPERTIES

Hercules AS4/3501-6 mechanical properties listed in Table 1 and Table 2 have been determined from laminate testing data generated by two independent firms. Table 1 data were generated by Delsen Labs in Glendale, California. The data used in Table 2 were generated by McDonnell Aircraft Company of St. Louis, Missouri. The same five prepreg lots were tested by both firms, and the results normalized to 5.2 mils per ply thickness unless otherwise noted.

The A370-5H/3501-6 fabric properties listed in Table 3 were derived from McDonnell Aircraft Company qualification data. Six prepreg lots are represented with results normalized to 14.0 mils per ply thickness.

The A and B allowable values shown are understood to be values above which a certain percentage of the population is expected to fail. The percentages for A and B allowables are 99% and 90%, respectively, with a confidence of 95%.

TABLE 1. DESIGN ALLOWABLE DATA FOR AS4/3501-6 UNIDIRECTIONAL TAPE

	\bar{X}	A	B	σ	n
0° flex strength (ksi)					
77°F	305.3	240.7	269.5	19.5	26
170°F wet ^a	235.2	109.2	209.1	14.6	30
0° flex modulus (msi)					
77°F	18.5	16.3	17.2	0.7	26
170°F wet ^a	19.0	16.5	17.6	0.9	30
0° tensile strength (ksi)					
-67°F	301.1	217.9	252.7	26.1	25
77°F	312.7	253.2	278.2	19.2	29
250°F	290.2	208.8	242.8	25.6	25
0° tensile modulus (msi)					
-67°F	20.7	18.2	19.2	0.8	25
77°F	20.7	17.9	19.1	0.9	29
170°F wet ^a	21.2	18.1	19.4	1.0	29
250°F	21.6	17.2	19.0	1.4	25
0° tensile strain (%)					
-67°F	1.34	1.05	1.17	0.09	25
77°F	1.40	1.10	1.20	0.08	28
170°F wet ^a	1.30	1.00	1.10	0.08	28
250°F	1.23	0.82	0.99	0.13	25
0° compressive strength (ksi)					
77°F	226.3	183.9	201.5	13.0	22
170°F wet ^{a,b}	158.3	107.6	128.8	15.8	24
0° compressive modulus (msi)					
77°F	20.2	16.9	18.3	1.0	22
170°F wet ^a	20.0	15.5	17.4	1.4	24

TABLE 1 (Cont)

	\bar{X}	A	B	σ	n
0° compressive strain, (%)					
77°F	1.3	1.0	1.1	0.8	22
170°F wet ^a	0.81	0.49	0.62	0.10	24
Short beam shear ^b (ksi)					
77°F	17.5	14.4	15.7	1.0	30
170°F wet ^a	12.0	10.1	10.5	0.2	30
90° tensile strength (ksi)					
77°F	7.84	4.14	5.65	1.2	30
170° wet ^a	3.12	2.16	2.56	0.3	35
90° tensile strength (msi)					
77°F	1.4	1.1	1.2	0.1	
170°F	1.33	1.03	1.15	0.10	35
90° tensile strain (%)					
77°F	0.674	0.302	0.458	0.121	
170°F wet ^a	0.242	0.146	0.204	0.022	35
$\gamma = 0.024$ Poissons ratio in 90° direction. $\gamma = 0.30$ Poissons ratio in 0° direction. a. Wet: moisture content of test specimens 1.1%; specimens conditioned in a chamber with 87% RH at 190°F b. Most of the failures were TAB failures					

**TABLE 2. SUMMARY OF AS4/3501-6 MECHANICAL PROPERTIES OF AVERAGES
WITH A AND B ALLOWABLES**

	\bar{X}	A	B	σ	n
Short beam shear (ksi)					
-67°F	22.7	17.0	19.3	1.6	15
77°F	18.0	14.1	15.7	1.2	23
250°F	13.2	9.7	11.2	1.1	25
250°F wet ^a	11.8	10.0	10.8	0.5	15
Flatwise tension (ksi)					
-67°F	2.75	0.75	1.57	0.55	14
77°F	3.48	1.90	2.56	0.50	25
250°F	2.05	1.17	1.54	0.24	14
90° tensile strength (ksi)					
-67°F	9.4	6.2	7.5	0.9	15
77°F	10.0	6.8	8.2	1.0	25
250°F	9.5	5.6	7.2	1.1	15
90° tensile modulus (%)					
-67°F	2.1	1.4	1.7	0.2	15
77°F	2.0	1.4	1.6	0.2	25
250°F	1.7	1.3	1.5	0.1	15
90° tensile strain (%)					
-67°F	0.471	0.260	0.347	0.059	15
77°F	0.565	0.302	0.411	0.083	25
250°F	0.639	0.299	0.439	0.095	15
0° compressive strength ^b (ksi)					
-67°F	311	201	246	30.7	15
77°F	292	202	240	28.3	25
250°F	240	145	184	26.4	15
0° compressive modulus ^b (msi)					
-67°F	21.2	17.6	19.1	1.0	15
77°F	21.1	18.9	19.8	0.7	25
250°F	20.4	16.5	18.1	1.1	15
0° compressive strain (%)					
-67°F	1.858	0.939	1.317	0.250	15
77°F	1.752	1.064	1.351	0.216	25
250°F	1.411	0.786	1.043	0.174	15

- a. Specimens were subjected to a 24-hour water boil before test. The 0° compressive and 90° tensile properties were tested using sandwich beams.
- b. Type 1 material: normalized to 5.2 mils per ply thickness.
Type 2 material: normalized to 10.4 mils per ply thickness.

**TABLE 3. DESIGN ALLOWABLE SUMMARY, A370-5H/3501-6 FABRIC
QUALIFICATION TO MMS-554**

	\bar{X}	A	B	σ	n
Warp tensile strength (ksi)					
-65°F	94.3	54.1	70.8	12.2	20
77°F	113.3	86.8	97.9	8.6	30
250°F	128.1	89.3	105.6	12.6	30
Warp tensile modulus ^a (msi)					
-65°F	9.8	8.8	9.2	0.3	20
77°F	10.3	9.7	9.9	0.2	30
250°F	9.7	8.8	9.2	0.3	30
Warp tensile strain (%)					
-65°F	0.96	0.61	0.76	0.12	40
77°F	1.12	0.89	0.99	0.08	59
250°F	1.28	1.05	1.15	0.08	47
Fill tension strength ^a (ksi)					
77°F	99.4	72.1	83.4	8.2	20
250°F	104.1	64.5	80.9	11.9	20
Fill tension modulus ^a (msi)					
77°F	9.9	9.2	9.5	0.2	20
250°F	9.4	8.0	8.6	0.4	20
Fill tensile strain (%)					
77°F	1.02	0.78	0.88	0.08	40
250°F	1.11	0.79	0.92	0.11	40
Warp compression strength ^a (ksi)					
-65°F	124.8	81.8	99.7	12.9	20
77°F	109.1	91.4	98.8	5.7	29
250°F	85.1	67.8	75.1	5.6	30
Warp compression modulus ^a (msi)					
-65°F	9.6	8.3	8.8	0.4	20
77°F	9.8	8.8	9.2	0.3	25
250°F	9.5	8.0	8.6	0.5	30

TABLE 3 (Cont)

	\bar{X}	A	B	σ	n
Warp compression strain (%)					
-65°F	1.58	0.86	1.17	0.25	50
77°F	1.32	0.72	0.97	0.21	50
250°F	1.07	0.75	0.89	0.11	47
Fill compression strength ^a (ksi)					
77°F	98.0	76.0	85.1	6.6	20
250°F	75.5	55.2	63.6	6.1	20
Fill compression modulus ^a (msi)					
77°F	9.3	8.3	8.7	0.3	19
250°F	9.1	8.1	8.5	0.3	20
Fill compression strain (%)					
77°F	1.24	0.47	0.79	0.26	38
250°F	0.96	0.63	0.77	0.11	39
Warp short beam shear (ksi)					
-65°F	11.4	7.4	9.1	1.3	30
77°F	11.3	7.6	9.2	1.2	30
250°F	8.9	6.1	7.3	0.9	30
250°F wet ^b	6.5	4.6	5.4	0.6	30
Fill short beam shear (ksi)					
77°F	11.1	8.1	9.4	0.9	20
250°F	8.6	5.9	7.0	0.8	20
Flatwise tensile strength (psi)					
-65°F	1.463	1.093	1.247	0.111	20
77°F	1.810	1.061	1.372	0.225	20
250°F	2.482	1.146	1.700	0.401	20
Tension bearing load ^a (lb)					
0°F	7.315	6.496	6.835	0.243	19
Tension bearing modulus ^a					
0°F	7.6	6.0	7.0	0.3	20
Tension bearing strain (%)					
0°F	0.51	0.42	0.46	0.03	38

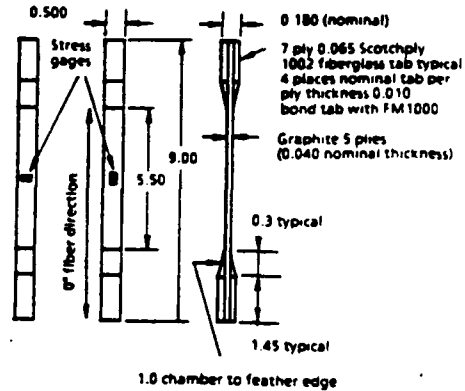
TABLE 3 (Cont)

	\bar{X}	A	B	σ	n
0/45 short beam shear (ksi) 77°F	9.3	6.3	7.6	0.9	20
Pin bearing load ^b (lb) 200°F	2.877	1.958	2.339	0.276	20
0/45 compression strength ^{a,c} (msi) 200°F	54.2	32.0	41.2	6.6	19
220°F	48.7	26.0	35.4	6.8	20
0/45 compression modulus ^{a,c} (msi) 200°F	6.7	5.7	6.1	0.3	19
220°F	6.7	6.0	6.3	0.2	20
0/45 compression strain ^c (%) 200°F	0.86	0.50	0.65	0.12	38
220°F	0.81	0.40	0.57	0.14	40
Warp hole tensile load (lb) 77°F	1.597	1.442	1.506	0.046	20
Warp hole tensile modulus (msi) 77°F	6.1	5.8	6.0	0.1	20
Warp hole tensile strain (%) 77°F	0.66	0.14	0.47	0.1	20
Warp hole compression load (lb) 77°F	1.903	1.627	1.741	0.388	20
Warp hole compression modulus (msi) 77°F	5.8	4.8	5.2	0.1	4
Warp hole compression strain (%) 77°F	0.88	0.65	0.74	0.05	8
a. Normalized values using 14.0 mils per ply thickness.					
b. 24-hour water boil.					
c. Specimens exposed to 160°F, 95% RH, to equilibrium.					

TESTING PROCEDURES

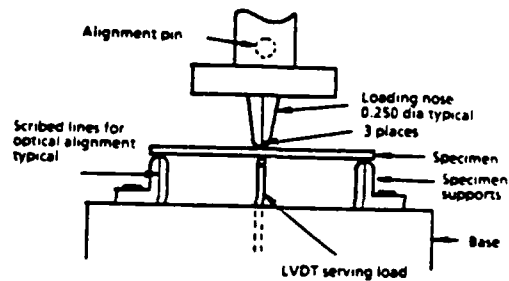
0° Tensile (unidirectional)

Test method: ASTM D-3039
 Specimen thickness: 0.040 to 0.049 in.
 Specimen width: 0.500 in.
 Gage length: 5.50 in.
 Rate of test: 0.05 in/min



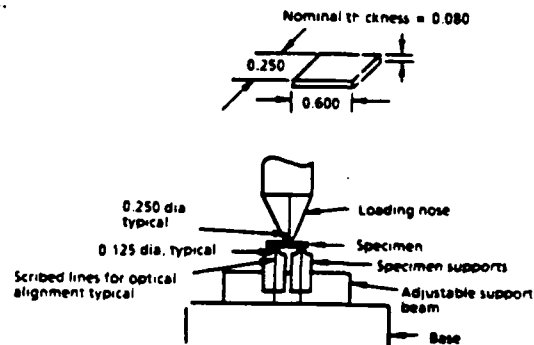
Flexure

Test method: ASTM D-790
 Specimen thickness: 0.081 to 0.095 in.
 Specimen width: 0.5 in.
 Span: 2.712 in.
 Rate of test: 0.05 in/min



Short Beam Shear

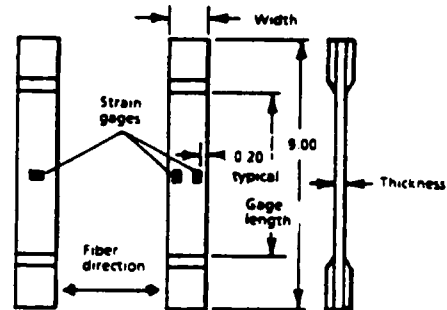
Test method: ASTM D-2344
 Specimen thickness: 0.083 to 0.095 in.
 Specimen width: 0.25 in.
 Span: 0.376 in.
 Rate of test: 0.05 in/min



TESTING PROCEDURES (CONT)

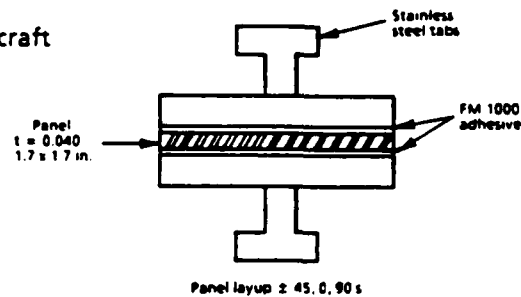
90° Tensile (unidirectional)

Test method: ASTM D-3039
 Specimen thickness: 0.083 to 0.095 in. (Figure 1)
 0.080 in. (Figure 2)
 Gage length: 5.000 in. (Figure 1)
 6.000 in. (Figure 2)
 Width: 1.000 in. (Figure 1)
 0.750 in. (Figure 2)
 Rate of test: 0.05 in/min



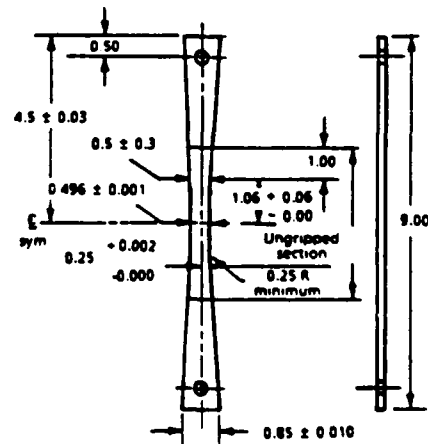
Flatwise Tensile

Test method: McDonnell Aircraft
 MMS-549
 Specimen thickness: 0.040 in.
 Width: 1.7 in.
 Length: 1.7 in.
 Rate of test: 0.01 in/min



0° Tensile (fabric)

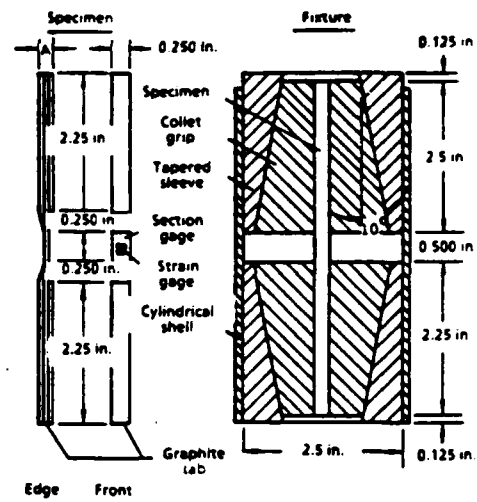
Test method: Boeing Aircraft
 BMS-212
 Neck width: 0.496 in.
 Nominal length: 9.0 in.
 Nominal thickness: 0.11 in.
 Rate of test: 0.05 in/min



TESTING PROCEDURES (CONT)

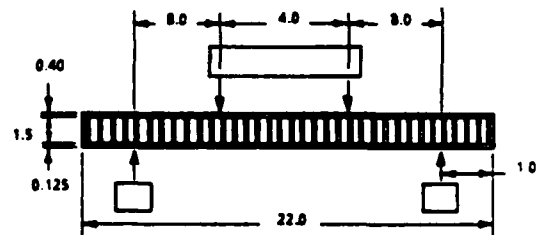
0° Compression (Figure 1)

Test method: ASTM D-3410-75
 Specimen thickness: 0.097 to 0.121 in.
 Gage length: 0.500 in.
 Width: 0.250 in.
 Rate of test: 0.05 in/min



0° Compression (Figure 2)

Test method: McDonnell Aircraft
 MMS-549
 Span: 20.0 in.
 Width: 1.000 in.
 Rate of test: 0.25 in/min



PROCESSING
CHARACTERISTICS

BLEEDER REQUIREMENT

Formula for calculating bleeders to be used:

$$A = \left(\frac{R.C.}{F.C.} \right) W_f - \left(\frac{R.V.}{F.V.} \right) \left(\frac{P_r}{P_f} \right) W_f$$

where

$$A = \text{amount of resin to be removed} \left(\frac{\text{lb}}{\text{in}^2 - \text{ply}} \right)$$

R.C. = prepreg resin content (w/o)

F.C. = prepreg filler content (w/o)

R.V. = laminate resin volume required (v/o)

F.V. = laminate fiber volume required (v/o)

P_r = resin density (lb/in³)

P_f = fiber density (lb/in³)

W_f = prepreg fiber weight (lb/in²)

When "A" has been determined, the number of bleeders required for the panel is calculated as follows:

5-mil prepreg	{	$N_{15} = \frac{(A)(n)}{K} - 2 \text{ (for prepreg resin content of 45\% max)}^a$ $N_8 = \frac{(A)(n)}{K} - 1 \text{ (for prepreg resin content of 45\% max)}^a$
10-mil prepreg	{	$N_8 = \frac{(A)(n)}{K} - 2 \text{ (for prepreg resin content of 45\% max)}^a$ $N_4 = \frac{(A)(n)}{K} - 1 \text{ (for prepreg resin content of 45\% max)}^a$

where

5-mil prepreg	{	$N_{15} = \text{number of bleeders for 15-ply laminate}$ $N_8 = \text{number of bleeders for 8-ply laminate}$
10-mil prepreg	{	$N_8 = \text{number of bleeders for 8-ply laminate}$ $N_4 = \text{number of bleeders for 4-ply laminate}$

$$A = \text{amount of resin to be removed} \left(\frac{\text{lb}}{\text{in}^2 - \text{ply}} \right)$$

n = number of plies in laminate

K = 8×10^{-5} lb/in² for type 120 glass

K = 17×10^{-5} lb/in² for type CD 1850 Machberg paper

a. For prepreg resin content above 45 w/o, the equations become:

$$N_n = \frac{(A)(n)}{K}$$

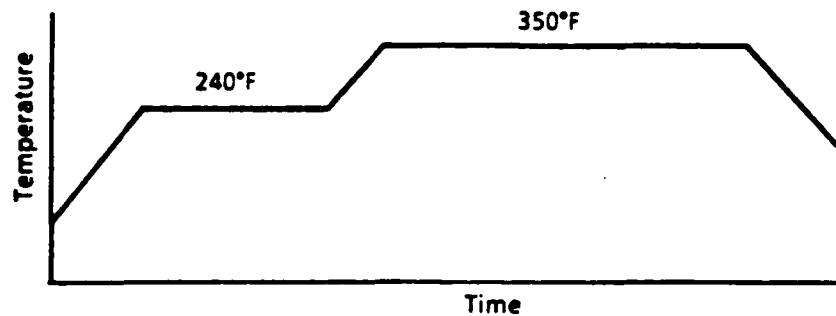
Experience has shown that a required fiber volume of 60 to 64 v/o can be consistently met if a F.V. of 59 is used in the calculation of "A". These formulae are based upon 3 x 10 in. acceptance laminates.

AS4/3501-6 RESIN

CHARACTERISTICS

CURE CYCLE FOR AS4/3501-6 TAPE & FABRIC

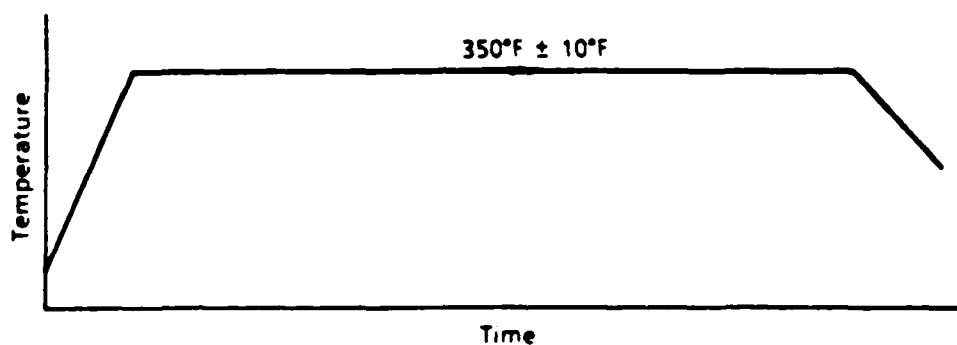
A suggested cure cycle is shown below. Other cure cycles have been used successfully with this resin system.



1. Place vacuum bagged layup in autoclave and close clave.
2. Apply minimum vacuum of 25 in. of Hg.
3. Apply 85 ± 5 psig.
4. At a rate of 3°F/minute to 5°F/minute, raise the laminate temperature to $240^{\circ}\text{F} \pm 10^{\circ}\text{F}$, while holding 85 ± 5 psig autoclave pressure and 20-29 in. of HG vacuum.
5. Hold at $240^{\circ}\text{F} \pm 10^{\circ}\text{F}$, $85 \text{ psig} \pm 5 \text{ psig}$ and 20-29 in. of Hg for 60 to 70 minutes.
6. Raise pressure to 100 ± 5 psig and vent the vacuum bag to ambient atmospheric pressure.
7. Raise temperature at a rate of 3°F/minute to 5°F/minute to $350^{\circ}\text{F} \pm 10^{\circ}\text{F}$. Hold for 120 ± 10 minutes under 100 ± 5 psig autoclave pressure.
8. At a rate of $5^{\circ}\text{F} \pm 1^{\circ}\text{F/minute}$ lower laminate temperature to 200°F . Release autoclave pressure.
9. Remove from autoclave and unbag.

POSTCURE FOR AS4/3501-6 TAPE & FABRIC

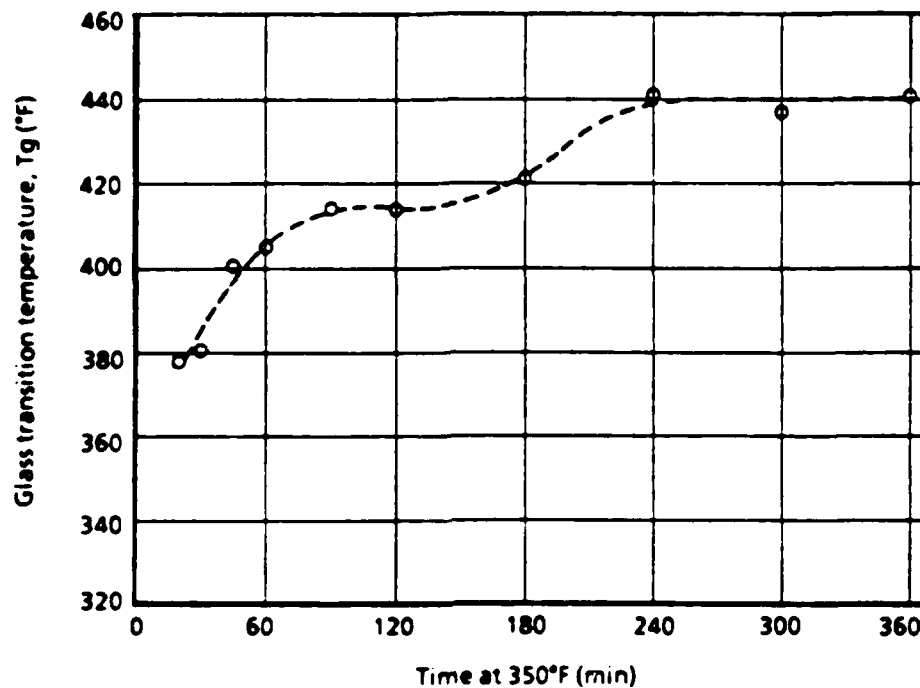
For high temperature applications, a postcure cycle is recommended to raise the laminate glass transition temperature (T_g). This procedure yields increased mechanical properties at elevated temperatures.



Postcure laminates as follows:

1. Heat to $350^{\circ}\text{F} \pm 10^{\circ}\text{F}$ for 30 minutes or more
2. Hold for 2 to 4 hours
3. Cool to 200°F in a minimum of 30 minutes with oven doors closed
4. Remove from oven

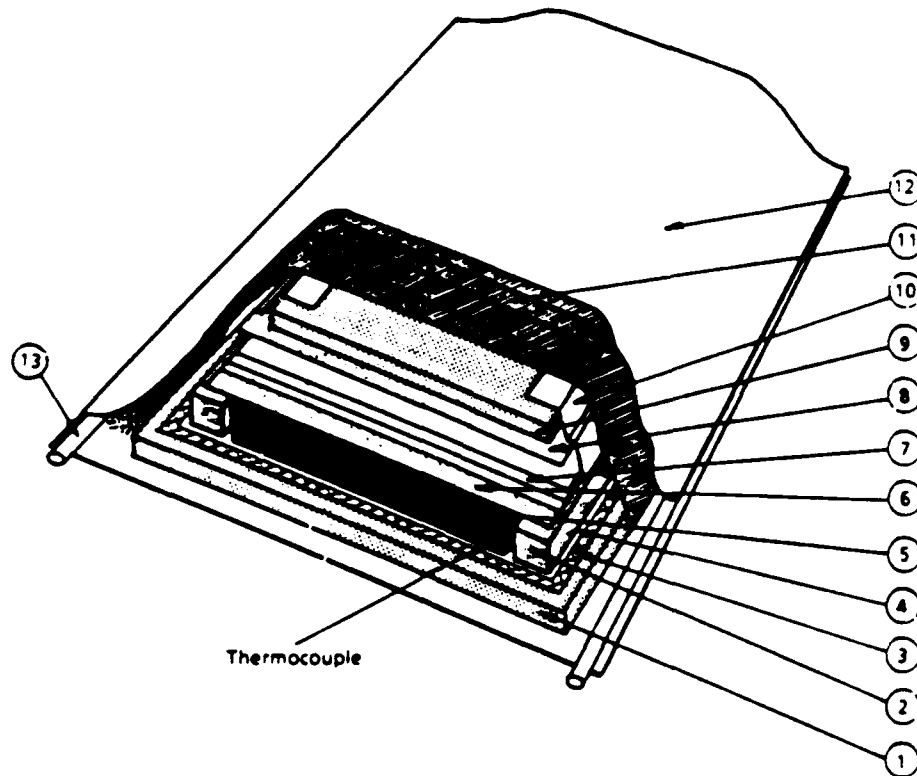
TIME AT TEMPERATURE VS Tg AND MODULUS OF COMPOSITE AS4/3501-6



The glass transition temperature specimens were prepared as follows:

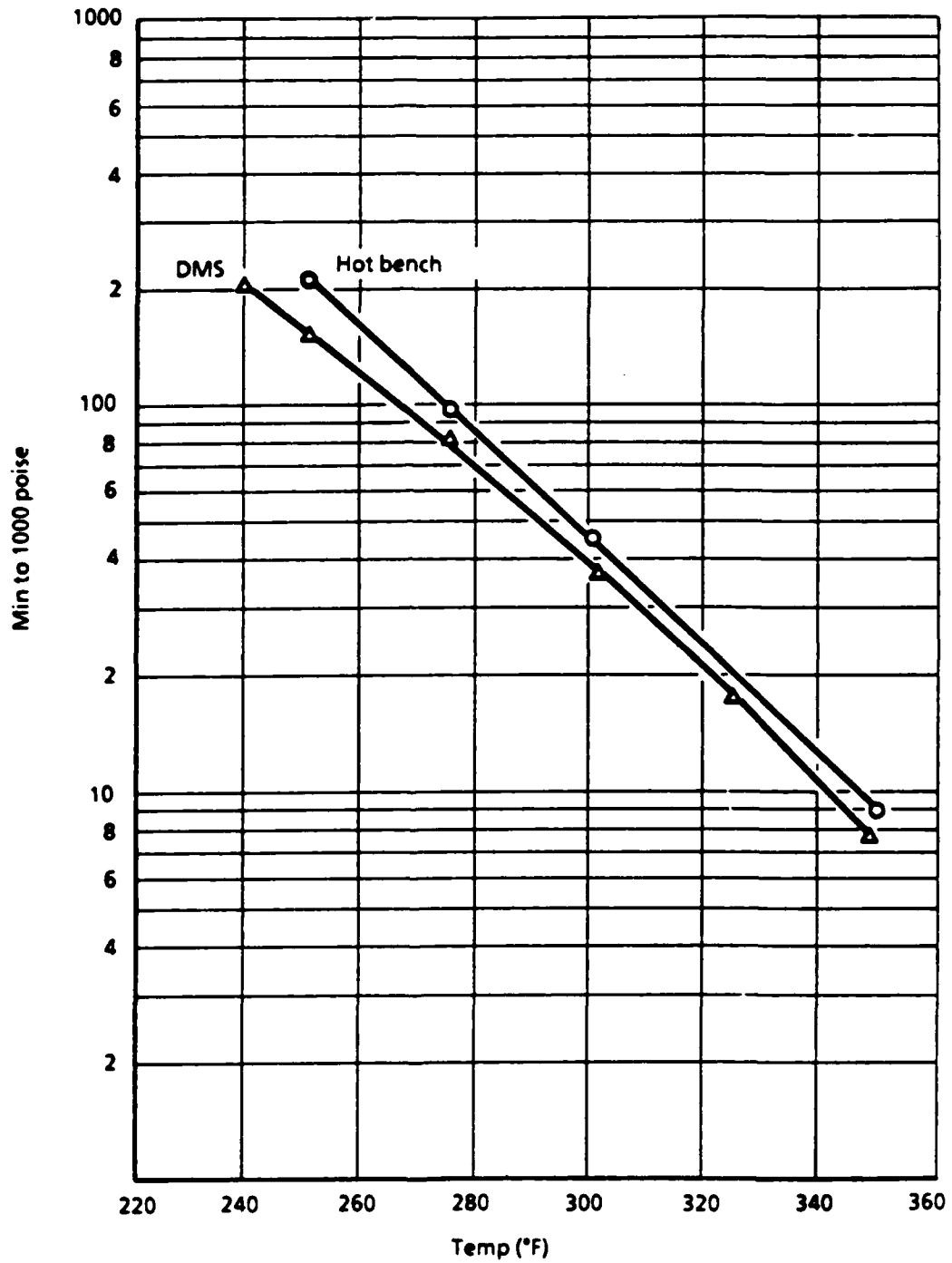
1. 20-minute sample used a 350°F press cure with no vacuum.
2. Autoclave samples were taken directly to 350°F with no-hold step
3. 30-180 minute samples came from same panel autoclave cured for 1/2 hour at 350°F with pressure and vacuum. Specified time at 350°F was achieved by postcuring each sample at 350°F.
4. 180-360 minute, samples came from same panel autoclave cured for 2 hours at 350°F with pressure and vacuum. Specified time at 350°F was achieved by postcuring each sample at 350°F.
5. 180 minute data point is the average of the preceding two samples.

TYPICAL ACCEPTANCE PANEL FABRICATION SEQUENCE

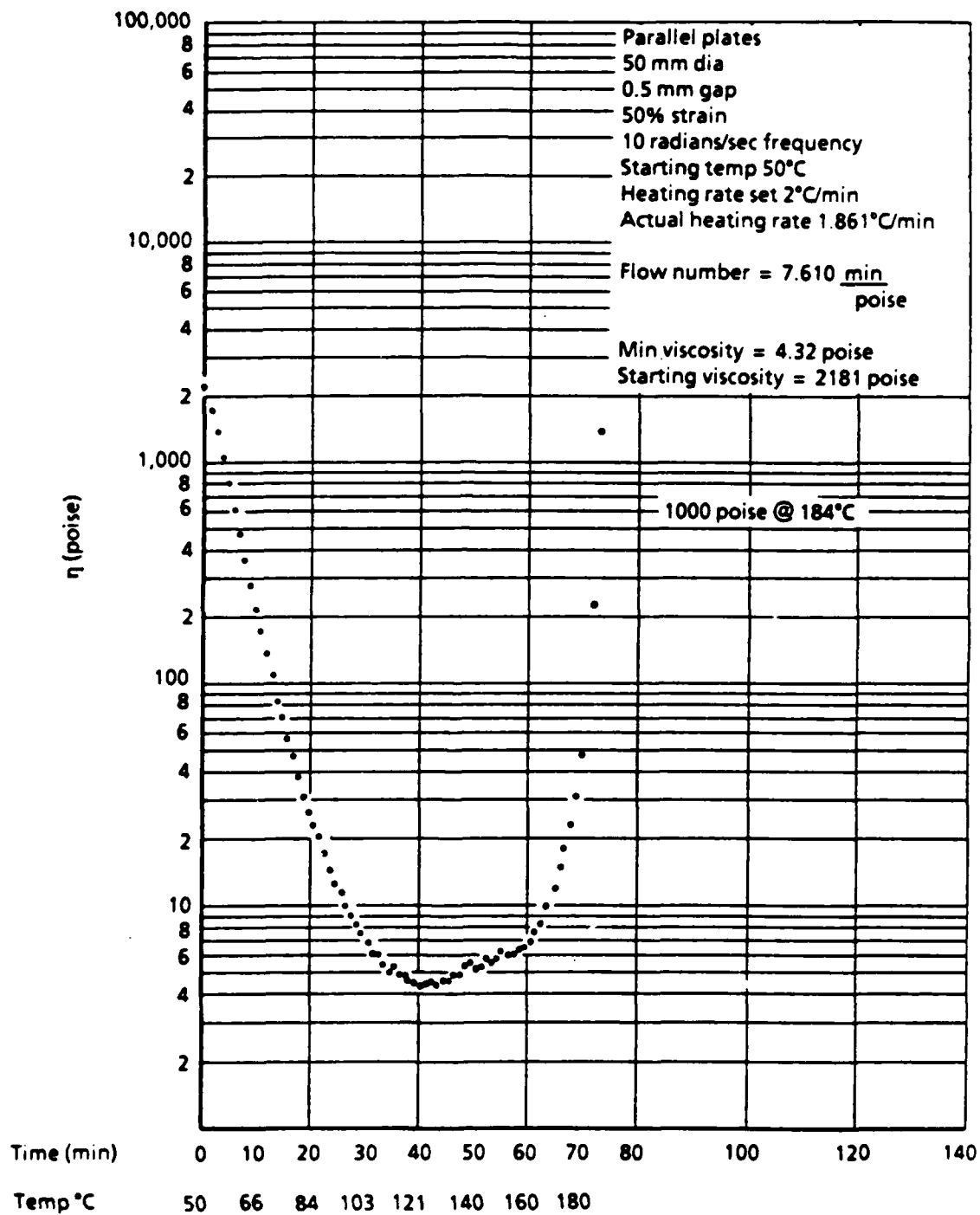


1. Base plate: Aluminum 1/4 to 1/2 in. thick
 2. Cork dam: Cork 1/8 x 1 in. with pressure-sensitive adhesive backing (corprene)
 3. Release film: Teflon, nonperforated 0.001-0.004 in. thick
 4. Release fabric: Fabric enfab TX 10-40 release (porous)
 5. Prepreg layup
 6. Release fabric: Fabric enfab TX 10-40 release (porous)
 7. Resin bleeders: Cloth, fiberglass no. 120 (prepreg to bleeder ply ratio 4:1 for 40 \pm 2% resin content and 4:1.5 for 42-44% resin content (following calculation on next page)
 8. Release film: Teflon, nonperforated 0.001-0.004 in. thick
 9. Caul plate: Aluminum, 0.080, 0.030 minimum thickness
 10. Tape: Pressure-sensitive, green polyester silicone
 11. Air bleeder: 1581 style glass; 4 plies over layup
 12. Vacuum bag: Film capron 80, hi-temp nylon, 0.002 in. thick
 13. High-temperature sealant: Schnee Morehead
- Mold release: Frekote-33 or equivalent

GEL TIME VS TEMPERATURE OF AS4/3501-6 RESIN



DYNAMIC VISCOSITY OF AS4/3501-6 RESIN



APPENDIX C3 - RIFLING TORQUE-STABILITY COMPUTATIONS

\$ ty sidehop.bas

```

10 REM THIS PROGRAM CALCULATES WORST-CASE SIDE HOP
20 REM S. DACKO
30 REM
35 DIM T(50)
40 J = 1461
50 REM NET MOMENT DATA
55 DATA 0
60 DATA 8750,13750,16000,12750
70 DATA 9750,4750,1750,-2250
80 DATA -3250,-4250,-10250
90 FOR I = 1 TO 10
100 READ T(I)
110 NEXT I
120 FOR I = 11 TO 50
130 T(I) = -10250
140 NEXT I
145 REM
146 TI = 0
150 REM START THE SIMULATION
155 PRINT "TIME,","ALPHA","V0","THETA","HOP HT,"
156 PRINT "MSEC ","R/S^2","R/S","RADS ","INCHES"
157 PRINT "-----","-----","-----","-----","-----"
160 REM
161 T = .001
162 X0 = 0
163 V0 = 0
164 REM
165 FOR I = 1 TO 50
170 ALPHA = T(I)/J
180 V = V0 + ALPHA*T
190 X = X0 + V0*T + .5*ALPHA*T^2
196 HOPHT = ATN(X)*88
200 PRINT TI,ALPHA,V0,X,HOPHT
210 X0 = X
220 V0 = V
230 TI = TI+T
240 NEXT I
250 END

```

\$ run sidehop

TIME, MSEC	ALPHA R/S^2	V0, R/S	THETA RADS	HOP HT, INCHES
----	----	----	----	----
0	0	0	0	0
.001	5.98905	0	.299452E-05	.263518E-03
.002	9.41136	.598905E-02	.136893E-04	.120465E-02
.003	10.9514	.154004E-01	.345654E-04	.304175E-02
.004	8.7269	.263518E-01	.652806E-04	.57447E-02
.005	6.67351	.350787E-01	.103696E-03	.912526E-02
.006	3.2512	.417522E-01	.147074E-03	.129425E-01
.007	1.19781	.450034E-01	.192676E-03	.169555E-01
.008	-1.54004	.462012E-01	.238107E-03	.209535E-01
.009	-2.2245	.446612E-01	.281656E-03	.247858E-01
.01	-7.01574	.424367E-01	.320585E-03	.282115E-01
.011	-7.01574	.354209E-01	.352498E-03	.310198E-01
.012	-7.01574	.284052E-01	.377396E-03	.332108E-01
.013	-7.01574	.213895E-01	.395277E-03	.347844E-01
.014	-7.01574	.143737E-01	.406143E-03	.357406E-01
.015	-7.01574	.735798E-02	.409993E-03	<u>.360794E-01</u> *

.016	-7.01574	.342232E-03	.406827E-03	.358008E-01
.017	-7.01574	-.667351E-02	.396646E-03	.349049E-01
.018	-7.01574	-.136893E-01	.379449E-03	.333915E-01
.019	-7.01574	-.020705	.355236E-03	.312608E-01
.02	-7.01574	-.277207E-01	.324007E-03	.285127E-01
.021	-7.01574	-.347365E-01	.285763E-03	.251471E-01
.022	-7.01574	-.417522E-01	.240503E-03	.211643E-01
.023	-7.01574	-.048768	.188227E-03	.016564
.024	-7.01574	-.557837E-01	.128936E-03	.113463E-01
.025	-7.01574	-.627995E-01	.626282E-04	.551128E-02
.026	-7.01574	-.698152E-01	-.106949E-04	-.941148E-03
.027	-7.01574	-.768309E-01	-.910337E-04	-.801096E-02
.028	-7.01574	-.838467E-01	-.178388E-03	-.156982E-01
.029	-7.01574	-.908624E-01	-.272759E-03	-.240028E-01
.03	-7.01574	-.978782E-01	-.374145E-03	-.329247E-01
.031	-7.01574	-.104894	-.482546E-03	-.424641E-01
.032	-7.01574	-.11191	-.597964E-03	-.526208E-01
.033	-7.01574	-.118925	-.720397E-03	-.633949E-01
.034	-7.01574	-.125941	-.849846E-03	-.747865E-01
.035	-7.01574	-.132957	-.986311E-03	-.867953E-01
.036	-7.01574	-.139973	-.112979E-02	-.994216E-01
.037	-7.01574	-.146988	-.128029E-02	-.112665
.038	-7.01574	-.154004	-.14378E-02	-.126526
.039	-7.01574	-.16102	-.160233E-02	-.141005
.04	-7.01574	-.168036	-.177387E-02	-.1561
.041	-7.01574	-.175051	-.195243E-02	-.171814
.042	-7.01574	-.182067	-.213801E-02	-.188144
.043	-7.01574	-.189083	-.23306E-02	-.205092
.044	-7.01574	-.196099	-.25302E-02	-.222657
.045	-7.01574	-.203114	-.273682E-02	-.24084
.046	-7.01574	-.21013	-.295046E-02	-.25964
.047	-7.01574	-.217146	-.317112E-02	-.279057
.048	-7.01574	-.224162	-.339879E-02	-.299092
.049	-7.01574	-.231177	-.363347E-02	-.319744

\$ 10

* CALCULATED WORST-CASE SIDE HOP FROM RIFLING TORQUE
IS 0.036 INCHES.

DESCRIPTION: OPERATIONAL PROCEDURES

STATUS: The complete set of operational procedures contained in this section reflect the current configuration and are not expected to change.

Some of the procedures may require minor rewording, different terminology or clean illustrations, however.

AUTHOR: Scott Dacko

Operational Procedures

A complete summary of LIHD operational procedures can be found in the IDF. Dwg. 12585710-825, pp. 1-26. Illustrations, timelines and step-by-step procedures in the form of "who, what, how, where, when, how long" have been created for emplacement, maximum rate of fire, sustained rate of fire, misfire, speedshift and displacement operations. Except for some terminology and precise loading control positions, the procedures are up-to-date.

These procedures--and the complete LIHD-human interface--has been developed with input and feedback from human factors, safety and other systems engineers at FMC. Members of the Fort Sill user community along with ARDEC personnel have also provided constructive input to the procedures.

Operational Design Considerations

The number of areas in which operational considerations played an important role in various aspects of the LTHD design are far too numerous to list. However, some of the considerations which had a significant impact on the design, along with the approaches taken, are discussed below.

- A lunette that is light enough for two 95th percentile men to lift off the truck pintle during emplacement and onto the pintle during displacement. The walking beam dimensions position the front wheels to allow a roughly 100 lb. lunette weight.

- Sufficient space for cannoneer 1 at all QE's and traverse angles. The trails are spread 25 degrees from center to allow room for a 95th percentile cannoneer 1 wearing a cold-weather, G.I. suit.

- Loading the bag charge into the breech at all loading QE's and traverse angles. A maximum loading QE of 600 mils provides the upper limit for a cannoneer with 95th percentile reach.

- Operating the fire control equipment, handpumps and tube lay controls at all QE's and traverse angles. Proper positioning and clearances provide the acceptable reaches and forces to be exerted for the 95th percentile man.

* Δ - DENOTES THE CONTROL LEVER POSITION THAT IS ⊥ TO THE BARREL.

12. PRIME MOVER (NOT SHOWN)

8. EMPLACEMENT CONTROLS

11. LUNETTE

EQUILIBRATOR ON/OFF VALVE
OFF ● ON Δ

CANNON POSITION - EMPLACE CONTROL
TOW ○ ● EMPLACE HOLD Δ

EQUILIBRATOR PRESSURE ADJUST VALVE
DECREASE ○ ● INCREASE HOLD Δ



EQUILIBRATOR PRESSURE TEST
TEST ○ ● GAGE OFF Δ

10. RIGHT TRAIL

3. RIGHT FRONT WHEEL CONTROL

4. RIGHT REAR WHEEL CONTROL

9. LEFT TRAIL

2. LEFT REAR WHEEL CONTROL
UP ○ ON/HOLD DOWN Δ

1. LEFT FRONT WHEEL CONTROL
OFF ○ ON/HOLD DOWN Δ


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OPERATIONAL PROCEDURES
EMPLACEMENT CONTROLS

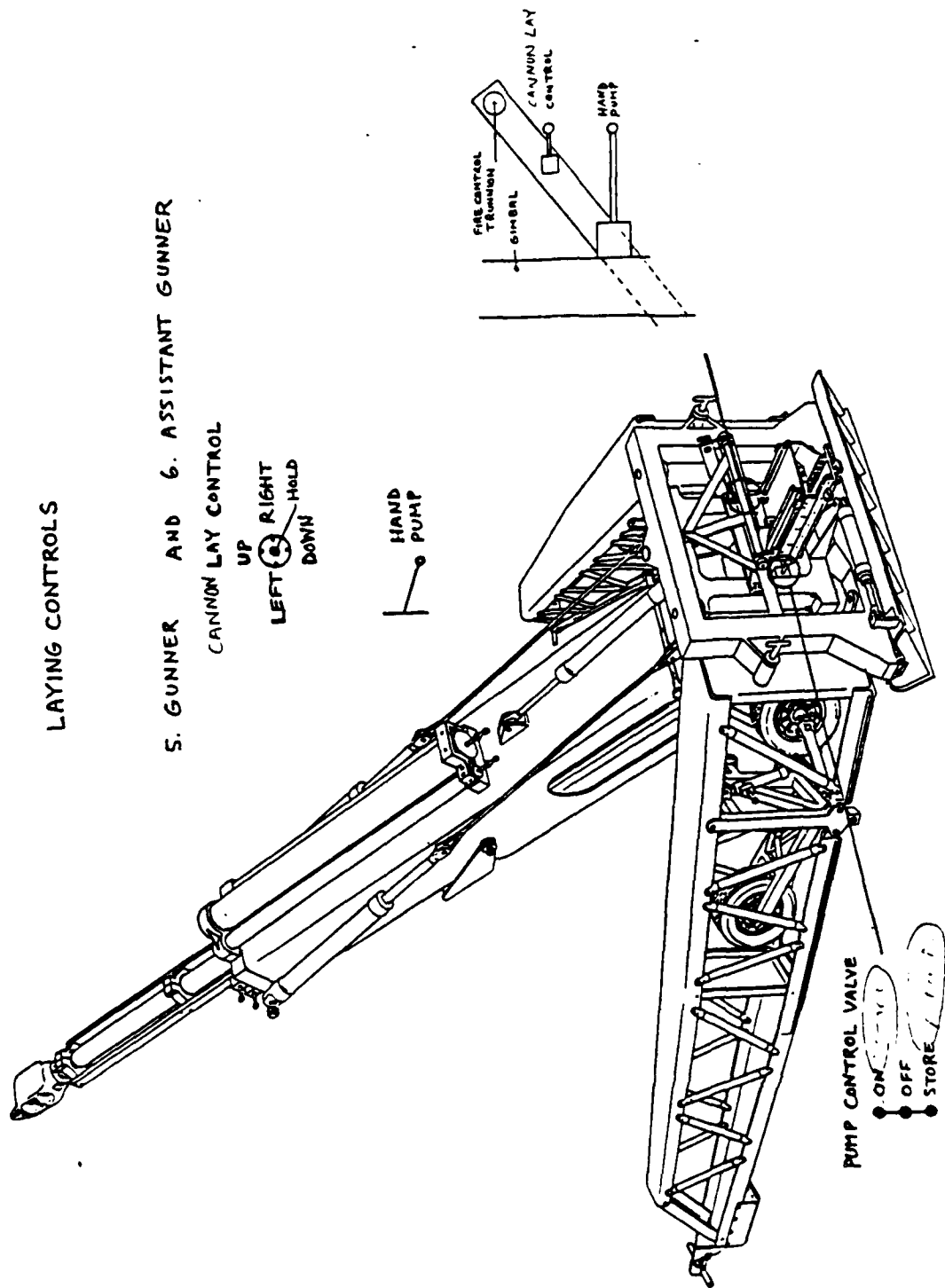
LAYING CONTROLS

5. GUNNER AND 6. ASSISTANT GUNNER

CANNON LAY CONTROL

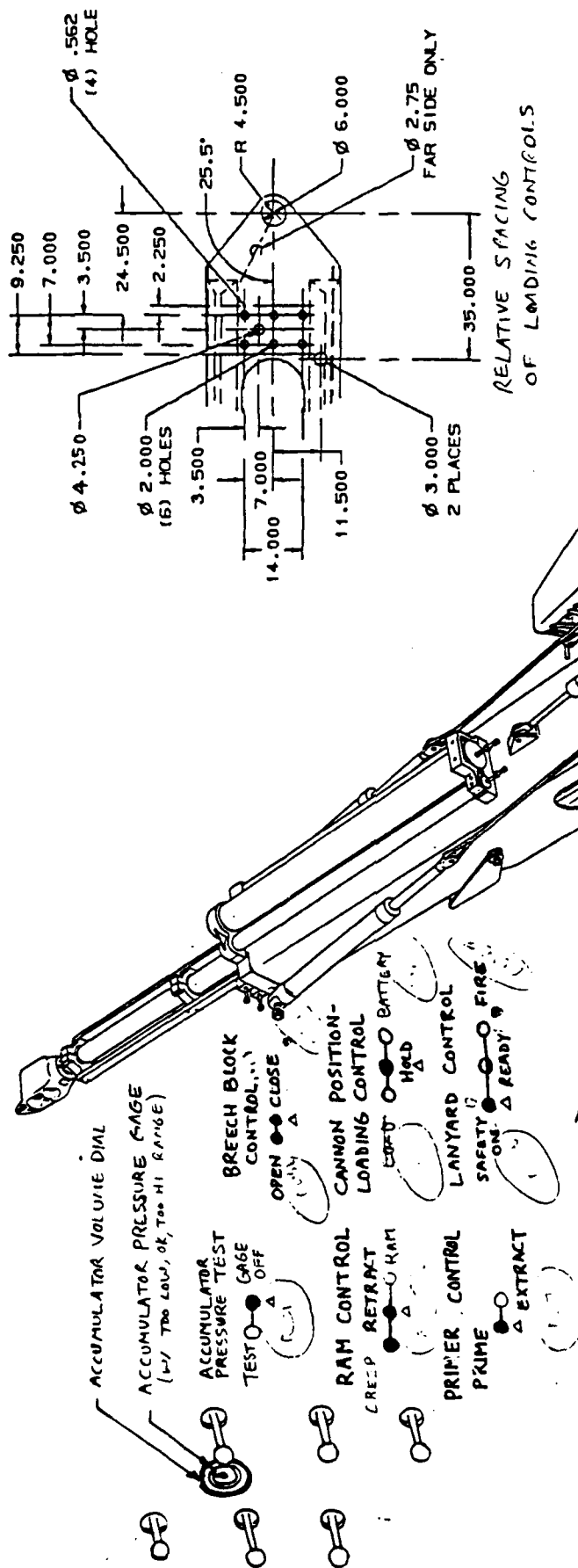
UP
LEFT  RIGHT
DOWN HOLD

HAND PUMP



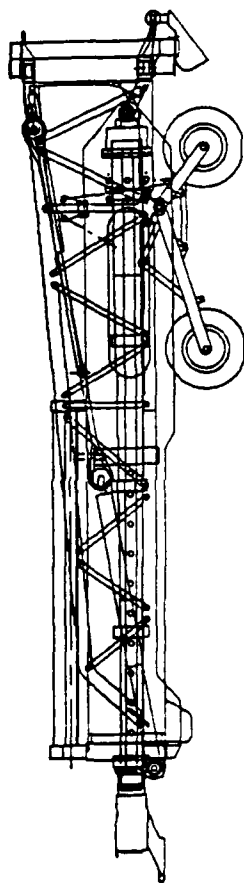
LAYING CONTROLS

7. LOADING CONTROLS

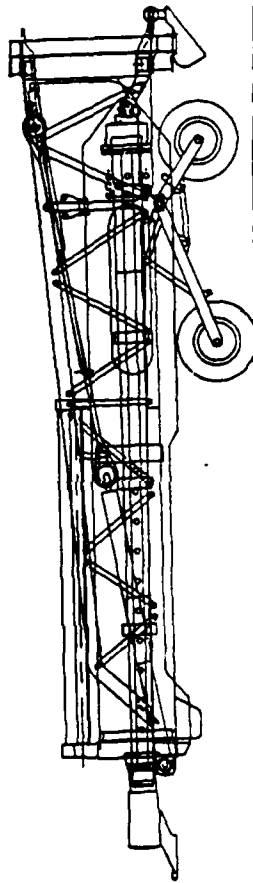


LOADING CONTROLS

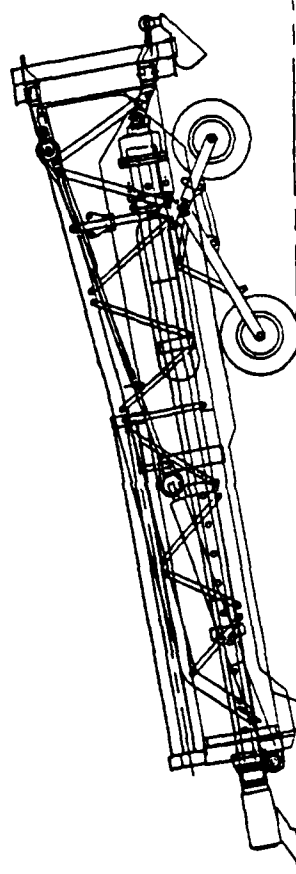
FMC LTHD - EMPLACEMENT PROCEDURE - ILLUSTRATED



TOW POSITION



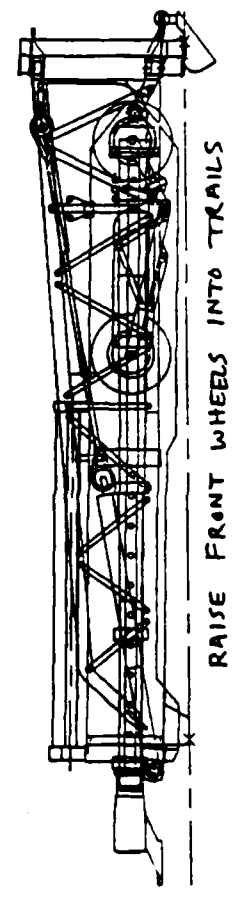
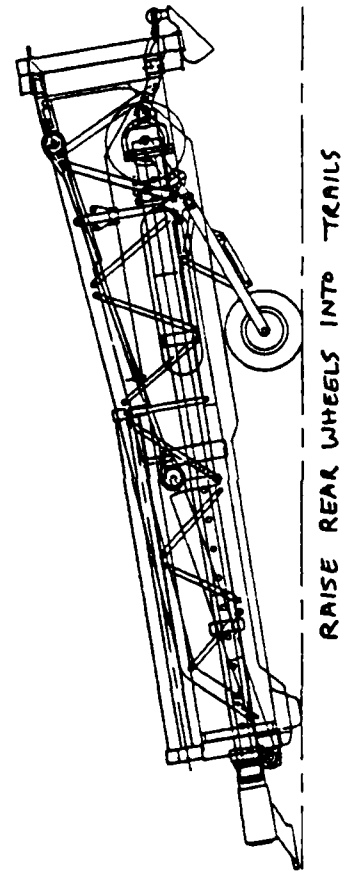
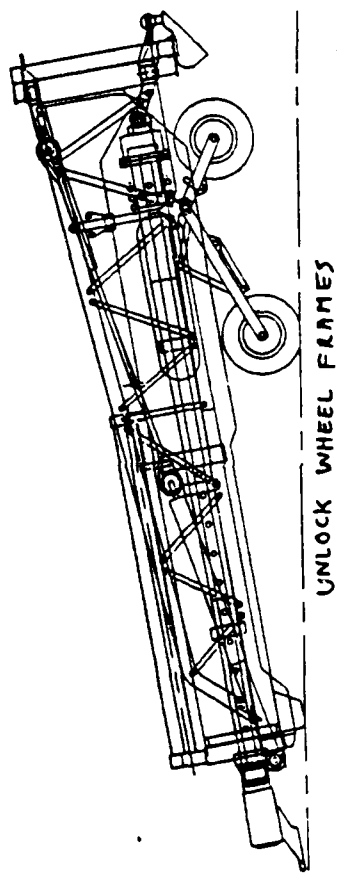
LOWER LTHD FRONT WHEELS



LOWER FRONT OF LTHD TO GROUND

EMPLACEMENT
PROCEDURE -
ILLUSTRATED

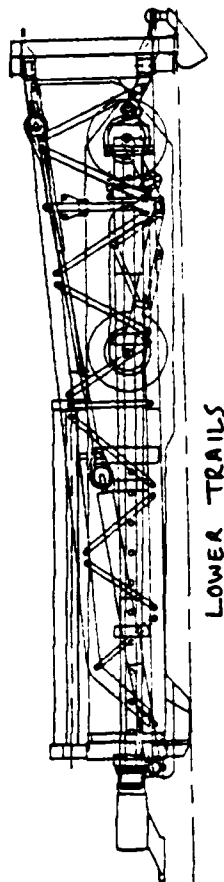
EMPLACEMENT PROCEDURE - ILLUSTRATED - CONT'D.



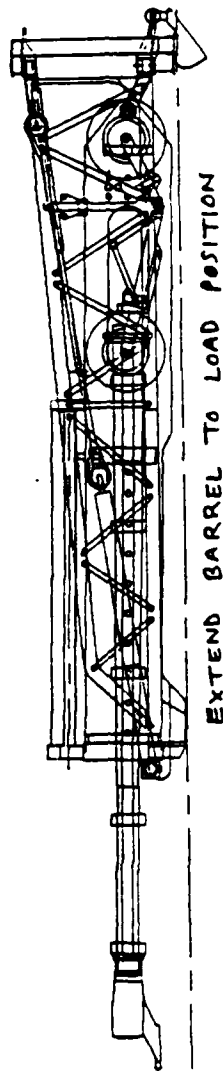
EMPLACEMENT
PROCEDURE -
ILLUSTRATED

EMPLACEMENT PROCEDURE - ILLUSTRATED - CONT'D.

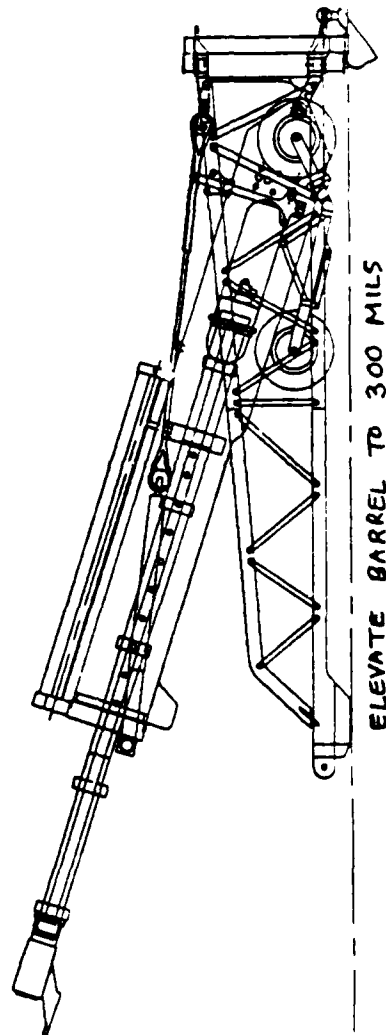
NOT SHOWN - ELEVATE TRAILS
SPREAD TRAILS
PIN TRAILS TO PLATFORM



LOWER TRAILS



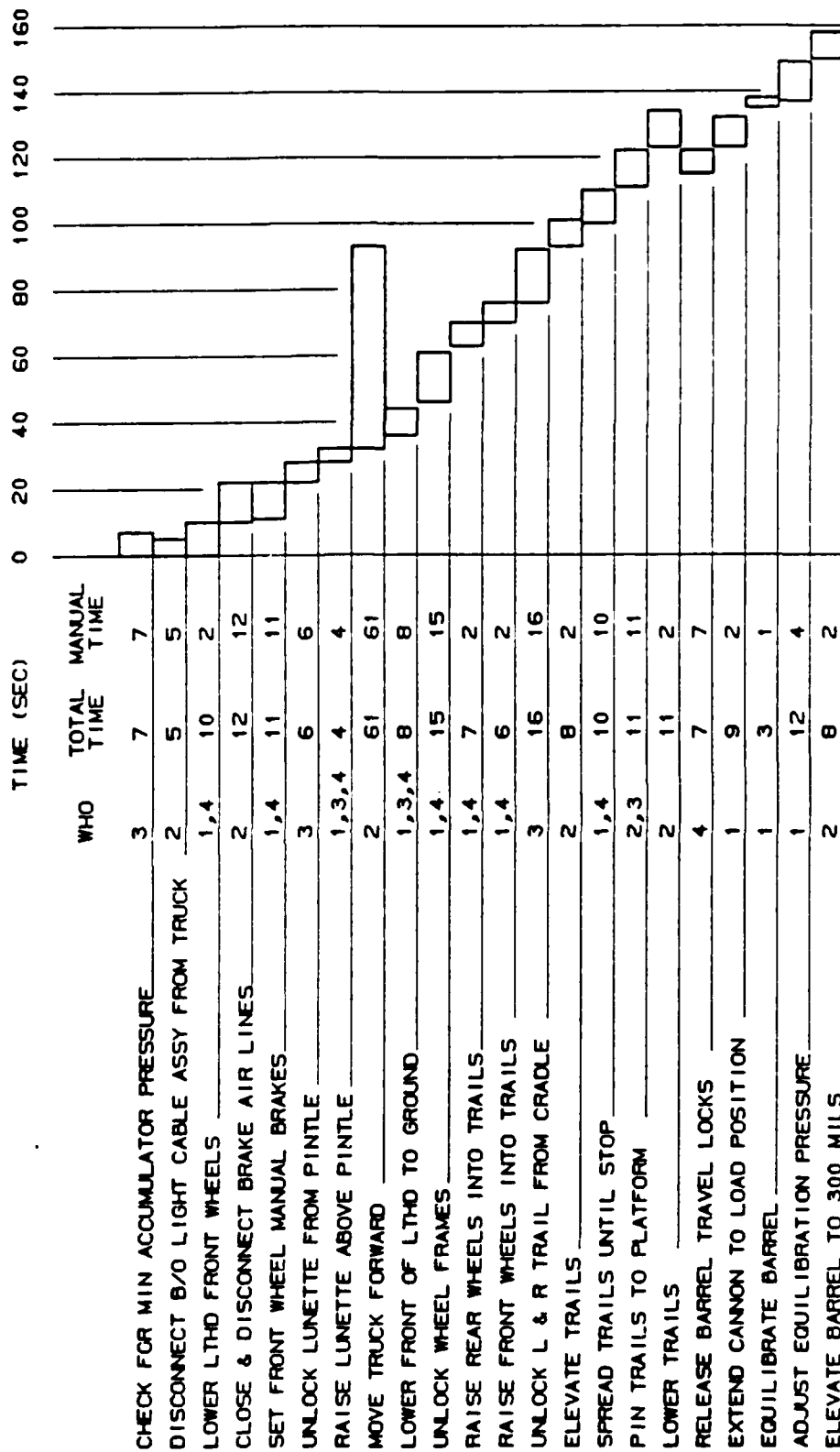
EXTEND BARREL TO LOAD POSITION



ELEVATE BARREL TO 300 MILS

EMPLACEMENT
PROCEDURE -
ILLUSTRATED

FMC LTHD EMPLACEMENT TIMELINE



EMPLACEMENT TIMELINE

FMC LTMD - ENPLACEMENT PROCEDURE

WHO	WHAT	HOW	WHERE	WHEN	HOW LONG
3	CHECK FOR MIN. ACCUMULATOR VOLUME	LOOK THRU HOLE ON L,R SIDE OF CRADLE AT ACCUMULATOR VOLUME INDICATOR. ADD UP TOTAL NO. OF NOTCHES SHOWING. IF TOTAL NO. OF NOTCHES GREATER THAN __: MAN. MOVE PUMP CONTROL VALVE FR OFF TO ON. 5 IF TOTAL NO. OF NOTCHES LESS THAN __: A. MAN. MOVE PUMP CONTROL VALVE FROM OFF TO STORE. B. MAN. PUSH ON HAND-PUMP HANDLES -- IN. ONE WAY AND __ TIMES UNTIL ABOVE MIN. PRESSURE. C. READ ACCUM. PRESSURE GAGE. IF ABOVE MIN. PRESSURE (3000 PSI): D. MAN. MOVE PUMP CNTRL VALVE FROM STORE TO ON. IF BELOW, KEEP PUMPING.	CRADLE - 0 L,R SIDE	0	8
2	DISC. BLACKOUT LIGHT CABLE ASSY FROM PRIME MOVER	A. MAN. DISCNCT P.M. B/O LT CABLE ASSY. B. MAN. CONNECT ASSY TO DUMMY COUPLING.	10 10	0 2	2 3
1,4	LOWER LTMD FRONT WHEELS	CONCURRENT ON LEFT AND RIGHT: A. MAN. MOVE FRT WHL CNTRL FR OFF THRU ON/HOLD TO DOWN UNTIL REAR WHLS ARE OFF GROUND ABOUT 3 INCHES. B. FRT WHLS LOWER TO LIFT REAR WHLS OFF GND. C. MAN. REL. FRT WHL CONTROL. RET'S TO ON/HOLD.	1,3 1,3	0 1 9	9 8 1
2	CLOSE & DISC. BRAKE AIR LINES	A. MAN. CLOSE SERVICE AIR LINE C/O COCK. B. MAN. CLOSE EMERGENCY AIR LINE CUTOFF COCK. C. MAN. UNCOUPLE SERVICE AIR LINE COUPLING. D. MAN. CONNECT SERV HOSE ASSY TO DUMMY CPLG. E. MAN. UNCOUPLE ENERG AIR LINE COUPLING. F. MAN. CONNECT SERV HOSE ASSY TO DUMMY CPLG.	12 12 12 10 12 10	10 12 14 16 18 20	2 2 2 2 2 2

EMPLACEMENT
PROCEDURE

EMPLACEMENT PROCEDURE - CONT'D.

WHO	WHAT	HOW	WHERE	WHEN	HOW LONG
1,4	SET FRONT WHEEL MANUAL BRAKES	CONCURRENT ON LEFT AND RIGHT: A. MAN. TAKE BRAKE HANDLES FR CLAMPED POS & PLACE IN SOCKET. B. MAN. PUSH DOWN ON HANDLE UNTIL STOPS. C. MAN. REPLACE HANDLE TO CLAMPED POS.	1,3 1,3 1,3	11 15 18	4 3 4
3	UNLOCK LUNETTE FROM PINTLE	A. MAN. REMOVE PINTLE COTTER PIN. B. MAN. RELEASE TOWING PINTLE LATCH.	12	22 26	4 2
1,3,4	RAISE LUNETTE ABOVE PINTLE	CONCURRENT ON LEFT AND RIGHT: MAN. HOLD HANDLES AT TRAIL ENDS, LIFTING VERT. TO RAISE LUNETTE UNTIL ABOVE PINTLE.	9,10	28	4
2	MOVE TRUCK FORWARD	DRIVE TRUCK UNTIL CLEAR OF LTHD.	12	32	61
1,3,4	LOWER FRONT OF LTHD TO GROUND	CONCURRENT ON LEFT AND RIGHT: MAN. HOLD HANDLES AT TRAIL ENDS, LOWER FRT OF LTHD TO GROUND.	9,10	36	8
1,4	UNLOCK WHEEL FRAMES	CONCURRENT ON LEFT AND RIGHT: A. PULL OUTWARD ON FRAME HANDLE. B. MAN. SWIVEL FRAME DOWN AGAINST FRT FRAME. C. RELEASE FRAME HANDLE.	2,4 2,4 1,3	46 51 56	5 5 5
1,4	RAISE REAR WHEELS INTO TRAILS	CONCURRENT ON LEFT AND RIGHT: A. MAN. MOVE REAR WHL CONTROL FR OFF THRU ON/ HOLD TO UP UNTIL RR WHLS RAISE & STOP. B. REAR WHLS RAISE INTO TRAILS AND STOP. C. MAN. REL. REAR WHL CONTROL. RET'S TO ON/HOLD.	2,4 -- 2,4	63 64 69	6 5 1
1,4	RAISE FRONT WHEELS INTO TRAILS, (REAR OF LTHD LOWERS TO GROUND)	CONCURRENT ON LEFT AND RIGHT: A. MAN. MOVE FRT WHL CONTROL FR ON/HOLD TO UP UNTIL FRT WHLS RAISE INTO TRAILS. B. FRT WHLS RAISE INTO TRAILS, REAR OF LTHD LOWERS TO GROUND. C. MAN. REL. FRT WHL CNTRL. RET'S TO ON/HOLD.	1,3 -- 1,3	70 71 75	5 4 1

EMPLACEMENT
PROCEDURES

EMPLACEMENT PROCEDURE - CONT'D

WHO	WHAT	HOW	WHERE	WHEN	HOW LONG
3	UNLOCK L & R TRAIL FROM CRADLE	A. MAN. PUSH ON LEFT PLUNGER PIN WITH THUMB. B. MAN. PULL & REMOVE PLUNGER PIN. C. MAN. SWIVEL TRAIL LOCK OUT & UP. D. MAN. REPLACE PLUNGER PIN IN HOLE. E. REPEAT ON RIGHT SIDE OF CRADLE.	9 9 9 9 10	76 77 79 81 84	1 2 2 3 8
2	ELEVATE TRAILS	A. MAN. MOVE CANNON LAY CNTRL FROM HOLD TO TO DOWN UNTIL TRAILS RAISE AND STOP. B. TRAILS RAISE AND STOP. C. MAN. REL CANNON LAY CNTRL, RET'S TO HOLD.	5/6 -- 5/6	93 94 100	7 6 1
1,4	SPREAD TRAILS UNTIL TRAILS STOP (TRAIL ANGLE IS 35 DEG)	CONCURRENT ON LEFT AND RIGHT: MAN. PUSH HORIZ & PERP TO TRAILS AT ENDS & WALK UNTIL TRAILS HIT STOPS.	9,10	100	10
2,3	LOCK TRAILS TO PLATFORM	CONCURRENT ON LEFT & RIGHT: A. MAN. PUSH ON SPRING-LOADED BOLT. B. MAN. ROTATE BOLT T-HEAD CW UNTIL TIGHT.	5,6 5,6	111 112	1 10
2	LOWER TRAILS	A. MAN. MOVE CANNON LAY CNTRL FR HOLD TO UP UNTIL TRAIL PADS PUSH ON GROUND. B. TRAILS LOWER, PADS PUSH ON GROUND. C. MAN. REL CANNON LAY CNTRL. RET'S TO HOLD.	5/6 -- 5/6	123 124 133	10 9 1
4	RELEASE BARREL TRAVEL LOCKS	A. MAN. PULL OUTWARD ON LEFT TRAVEL LOCK LEVER UNTIL STOPS. B. MAN. PULL OUTWARD ON RIGHT TRAVEL LOCK LEVER UNTIL STOPS.	8 8	115 120	2 2
1	EXTEND CANNON TO LOAD POSITION	A. MAN. MOVE CANNON POS-EMPLACE CNTRL FR HOLD TO EMPLACE UNTIL BARREL STOPS. B. BARREL MOVES FORWARD, BARREL STOPS. C. MAN. REL. CANNON POS-EMPLACE LEVER.	8 -- 8	123 124 131	8 7 1
1	EQUILIBRATE BARREL	A. MAN. MOVE EQUIL ON/OFF VALVE FR OFF TO ON. B. BARREL EQUILIBRATES.	8 --	135 136	1 2

EMPLACEMENT
PROCEDURE

TIMELINE FOR MAX RATE OF FIRE - BELOW 600 MIL^c (18.8 SEC / CYCLE)

WHAT	WHO	TIME (SEC)	TIME (SEC)															
			TOTAL	HANDAL	0	1	2	3	4	5	6	7	8	9	0	1	2	3
RECOIL	--	.22			*													
C' RECOIL TO LOAD POSITION	--	1.78			***													
OPEN BREECH	1	1.0	0.5			**												
SHAB CHAMBER	1	2.8	2.8															
RAM AND RETRACT	1	4.8	0.5															
LIFT CHARGE TO WINDOW	1	3.5	3.5															
POSITION CHARGE IN BREECH	1	2.5	2.5															
CLOSE BREECH	1	1.5	1.0															
MOVE BARREL INTO BATTERY	1	1.9	1.0															
CYCLE PRIMER AUTOLOADER	1	1.8	1.0															
FIRE PROJECTILE	1	0.8	0.3															
STAGE PROJECTILE	3	15.0	15.0															
STAGE BAG CHARGE	2	15.0	15.0															

MAX RATE OF FIRE
TIMELINE

LOADING PROCEDURE, MAX RATE OF FIRE - CONT'D

1	MOVE BARREL INTO BATTERY	A. MAN. MOVE CANNON FOR LOAD ENTER LEVER UP HOLD TO BATTERY UNTIL STOPS IN BATTERY. B. SWHEEL MOVES TO BATTERY FOR A STOPS. C. MAN. REL CANNON FOR LOAD ENTER LEVER. RETURNS TO HOLD.	CI -- CI	14.7 14.9 15.7	0.5 0.9 0.5
1	CYCLE PRIMER AUTOLOADER	A. MAN. MOVE PRIMER ENTER LEVER UP PRIME TO EXTRACT. B. SPENT PRIMER IS EXTRACTED. C. MAN. REL. PRIMER ENTER LEVER. RET'S TO PRIME. D. NEW PRIMER IS INSERTED.	CI -- CI --	15.2 15.7 17.1 17.3	0.5 0.4 0.5 0.4
1	FIRE PROTECTILE	A. ON FIRE COMMAND, MAN. MOVE LIMITED CONTROL LEVER UP READY TO FIRE. RET'S TO READY. B. FIRING PIN STOPS PRIMER.	CI --	18.9 19.5	0.5 0.7
1	STAGE PROTECTILE	A. PLACE PROTECTILE IN TRAY. B. MAN. CARRY PROTECTILE TO READY.	TRAY	11.1 15.1	4.0 11.0
2	STAGE SAC CHARGE	MAN. CARRY SAC CHARGE TO TRAIL.	TRAIL	4.0	15.0

FIRING BETWEEN 600 AND 800 RPS:

LOWER BARREL DURING TIME OF COUNTER-RECOIL TO LOW POSITION (1.70 SEC); ELEVATE BARREL & ADJUST FIRE CONTROL DURING
TIME BARREL MOVES INTO BATTERY (1.9 SEC) + TIME PRIMER AUTOLOADER IS CYCLED (1.8 SEC) + 1.5 ADDITIONAL SEC. TOTAL
CYCLE TIME = 20.7 SEC.

MAX RATE OF FIRE
PROCEDURES

(FILE: SUSTF)

FMC LTND - LOADING PROCEDURE, SUSTAINED FIRING

WHAT	HOW	WHERE
HOWITZER RECOILS TO 8.75 FT MAX. (8.5 FT W/ HOT ZONE 85)	PROJECTILE FIRES, RECOIL MECH ACTIVE.	--
HOWITZER COUNTER-RECOILS, BARREL STOPS AT LOAD POSITION	COUNTER-RECOIL CYL ACTIVE.	--
CHECK FOR MIN ACCUMULATOR PRESSURE	LOOK AT ACCUMULATOR PRESSURE GAGE. CHECK IF NEEDLE IS ABOVE "LOAD AND FIRE" MARK ON VOLUME DIAL. IF ABOVE, CONTINUE. IF BELOW, PUMP WITH HAND-PUMP.	
OPEN BREECH BLOCK	A. MAN. MOVE BREECH BLOCK CONTROL LEVER FR CLOSE TO OPEN, RELEASE LEVER. B. BREECH BLOCK OPENS & STOPS.	CI
SWAB CHAMBER	A. MAN. INSERT SWAB, REAR END FIRST, THRU CRADLE WINDOW. B. MAN. INSERT SWAB IN CHAMBER, REMOVE. C. REMOVE SWAB FR CRADLE WINDOW. D. WIPE OBTURATOR SPINDLE ASSY W/ SWAB.	CI CI CI CI
CHECK FOR CLEAR BORE	A. LOOK THROUGH TUBE. B. CALL "BORE CLEAR."	CI
REPLACE PRIMER DRUM EVERY 20 ROUNDS CLEAN PRIMER VENT EVERY 20 ROUNDS	MAN. REMOVE PRIMER DRUM, REPLACE. MAN. CLEAN PRIMER VENT WITH VENT- CLEANING TOOL, REAMING TOOL OR PRIMER CHAMBER CLEANING BRUSH.	CI
ENTER DEFLECTION ON M171 TELESCOPE & QUADRANT MOUNT	A. TURN AZIMUTH KNOB UNTIL DEFLECTION APPEARS IN DEFLECTION COUNTER. B. READ SETTING TO CHIEF OF SECTION.	5

SUSTAINED RATE OF FIRE
PROCEDURES

LOADING PROCEDURE - SUSTAINED FIRING - CONT'D

WHAT	HOW	WHERE
CHECK LEVEL & ADJ LEVEL OF M171 TEL & QUADRANT MOUNT	<ul style="list-style-type: none"> A. CHK FOR CENT BUBBLE IN CROSS LEVEL VIAL. B. TURN CROSS LEVEL CONTROL KNOB TO ADJ. C. CHK FOR CENT BUBBLE IN PITCH LEVEL VIAL. D. TURN PITCH LEVEL CONTROL KNOB TO ADJ. E. CHK FOR ZERO IN ELEV CORRECT COUNTER. F. TURN ELEV CORRECT KNOB TO ZERO COUNTER. 	5
CHECK LAY & LAY ON COLLIMATOR/ AIMING STAKES	<ul style="list-style-type: none"> A. SIGHT THROUGH EYEPiece OF M171. B. MAN. MOVE CANNON LAY CNTRL FR HOLD TO L/R S/6 UNTIL PROPER SIGHT PICT IS OBTAINED. C. RE-CHK FOR CENTERED BUBBLES ON LEVEL INDIC. 	5
ENTER QUADRANT ON M18 FIRE CONTROL QUADRANT	<ul style="list-style-type: none"> A. ROTATE ELEVATION CONTROL KNOB UNTIL QUADRANT APPEARS IN ELEVATION COUNTER. B. READ SETTING TO CHIEF OF SECTION. 	6
CHECK LEVEL & ADJ LEVEL OF M18	<ul style="list-style-type: none"> A. CHK FOR CENT BUBBLE IN CROSS LEVEL VIAL. B. TURN CROSS LEVEL CONTROL KNOB TO ADJ. 	6
MOVE CANNON TUBE TO QUADRANT & CHECK ELEV LEVEL	<ul style="list-style-type: none"> A. CHK FOR CENT BUBBLE IN ELEV LEVEL VIAL. B. MAN. MOVE CANNON LAY CNTRL FR LOCK TO U/D S/6 UNTIL BUBBLE CENT IN ELEV LEVEL VIAL. 	6
RAM PROJECTILE & TRAY, RETRACT TRAY	<ul style="list-style-type: none"> A. MAN. MOVE RAM CNTRL LEVR FR RETRACT TO RAM. REL. LEVER. RET'S TO RETRACT. B. LOAD TRAY/PROJ ADVANCES, TRAY STOPS. C. PROJECTILE RAMS. D. LOAD TRAY AUTO RETRACTS, STOPS AT PLATFM. 	CI -- -- --
POSITION CHARGE IN BREECH	<ul style="list-style-type: none"> A. MAN CARRY BAG CHARGE FR TRAIL TO BREECH. B. MAN. LIFT CHARGE THRU CRADLE WINDOW & PLACE AHEAD OF SWISS NOTCH IN BREECH. 	CI
CLOSE BREECH BLOCK	<ul style="list-style-type: none"> A. MAN. MOVE BREECH BLOCK CNTRL LEVER FR OPEN TO CLOSE. REL. LEVER. B. BREECH BLOCK SWINGS CLOSED. C. OBSERVE WITNESS MARKS. 	CI -- CI

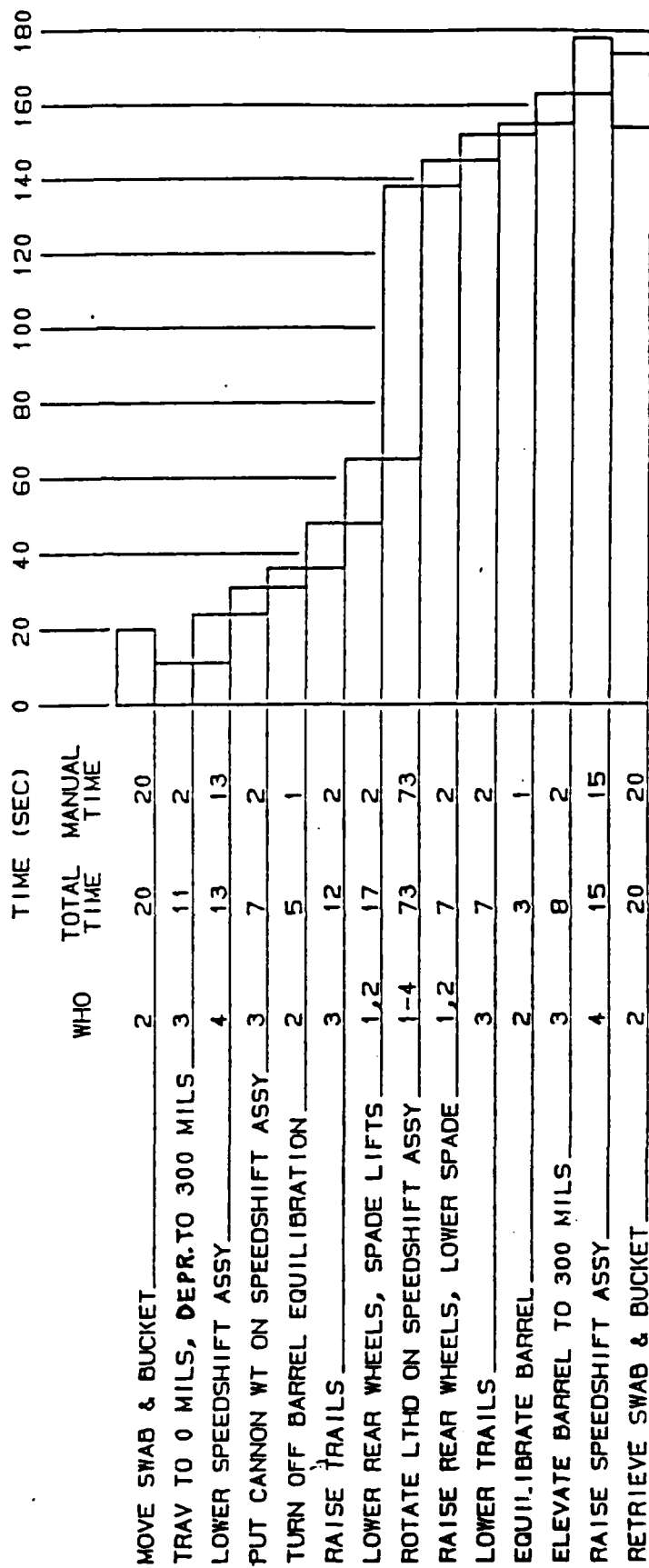
SUSTAINED RATE OF FIRE
PROCEDURE

LOADING PROCEDURE - SUSTAINED FIRING - CONT'D.

WHAT	HOW	WHERE
MOVE BARREL INTO BATTERY	A. MAN. MOVE CANNON POS LOAD CNTRL LEVER FR HOLD TO BATTERY UNTIL STOPS IN BATTERY. B. BARREL MOVES TO BATTERY POS & STOPS. C. MAN. REL. CANNON POS LOAD CNTRL LEVER. RET'S TO HOLD.	C1 -- C1
CYCLE PRIMER AUTOLOADER	A. MAN. MOVE PRIMER CNTRL LEVER FR PRIME TO EXTRACT. SPENT PRIMER IS EXTRACTED. B. MAN. REL. PRIMER CNTRL LEVER. RET'S TO PRIME. NEW PRIMER IS INSERTED.	C1
FIRE PROJECTILE	ON FIRE COMMAND, MAN. MOVE LANYARD CONTROL FR READY TO FIRE. RET'S TO READY.	C1
STAGE PROJECTILE	A. SET PROJECTILE IN TRAY. B. MAN. CARRY PROJECTILE TO TRAY.	TRAY
CUT BAG CHARGE	MAN. CUT BAG CHARGE TO REQ'D NUMBER.	CHARGE
STAGE BAG CHARGE	MAN. CARRY BAG CHARGE TO TRAIL.	9

SUSTAINED RATE OF FIRE
PROCEDURES

SPEEDSHIFT TIMELINE



SPEEDSHIFT TIMELINE

FILE: SPEEDSH

FNC LTND - SPEEDSHIFT PROCEDURE

WHO	WHAT	HOW	WHERE	WHEN	HOW LONG
2	MOVE BUCKET, SWAB	MAN. PICK UP BUCKET, SWAB, MOVE OUT OF SPEEDSHIFT RADIUS.	TRAIL	0	20
3	MOVE BARREL TO APPROX 0 MIL TRAVERSE & 300 MIL OE	A. MAN. MOVE TUBE LAY CNTRL FR HOLD TO L/R UNTIL NOTCHES ON GIMBAL & PLATF ALIGN. B. BARREL MOVES TO 0 DEG TRAV, NOTCHES ALIGN. C. MAN. MOVE TUBE LAY FR L/R TO UP/DWN UNTIL CRADLE MARK (SPSHT CG) IS 5 FT OFF GROUND. D. BARRELS MOVES TO 300 MILS. E. MAN. REL TUBE LAY. RET'S TO HOLD.	5/6	0	5
4	SWIVEL DOWN SPEEDSHIFT ASSY	A. MAN. PULL SPRING-PIN ON SPEEDSHIFT ASSEMBLY. B. MAN. SWIVEL OUT SP SHIFT ASSY. AUTO PINS IN DOWN POSITION. C. RETR. SP SHIFT DISK FR BII BOX & PLACE ON END OF SP SH ASSY.	SP. SH. ASSY	11	5
3	PUT CANNON WT ON SPEEDSHIFT ASSY	A. MAN. MOVE TUBE LAY FR HOLD TO DOWN UNTIL CANNON WT ON ASSY, & STOPS. B. CANNON LOWERS TO ASSY, STOPS. C. MAN. REL. TUBE LAY. RET'S TO HOLD.	5/6	24	6
	TURN OFF BARREL EQUILIBRATION	A. MAN. MOVE EQUIL ON/OFF FR ON TO OFF. B. PRESSURE DROPS, BARREL EQUIL STOPS.	8	31	1
3	RAISE TRAILS, LIFTING OFF GROUND	A. MAN. MOVE CANNON LAY FR HOLD TO DOWN UNTIL TRAILS RAISE AND STOP. B. TRAILS RAISE AND STOP. C. MAN. REL CANNON LAY. RET'S TO HOLD.	5/6	36	11
1,2	LOWER REAR WHEELS, LIFTING SPADE	CONCURRENT OPERATION ON LEFT AND RIGHT: A. MAN. MOVE REAR WHL CNTRL FR ON/HOLD TO DOWN UNTIL BOTTOM OF SPADE CLEARS GROUND BY 1 FT. B. RR WHLS LOWER, SPADE OFF GND BY 1 FT. LTND CLOSE TO BALANCE AT SPSHFT ASSY. C. MAN. REL. RR WHL CNTRL. RET'S TO ON/	2,4	48	16
			2,4	49	15
			2,4	64	1

SPEEDSHIFT
PROCEDURE

SPEEDSHIFT PROCEDURE - CONT'D.

WHO	WHAT	HOW	WHERE	WHEN	HOW LONG
3	ROTATE LTHD ON SPEEDSHIFT ASSY				
1-4		A. MAN. LIFT UP RR PLATF TO BAL ON SS ASSY.	PLATFM	65	8
1-4		B. MAN. HOLD LUM., TRAIL HANDLES, PLATF AT WAIST HT AND MAN. PUSH HORIZ. ROTATING CW TO NEW POSITION.		73	60
		IF EXTREMELY HARD GROUND: MARK HOLE LOC'S FOR SPADE, ROTATE LTHD, DIG HOLES, ROTATE TO NEW FIRE POS.			
4		C. MAN. PUSH UP ON LUNETTE TO RETURN WT TO RR WHLS.	11	133	5
1,2	RAISE REAR WHEELS, LOWERING SPADE				
		CONCURRENT OPERATION ON LEFT AND RIGHT:			
		A. MAN. MOVE REAR WHL CNTRL FR ON/HOLD TO UP UNTIL WHLS STOP.	2,4	138	6
		B. RR WHLS RAISE, STOP, SPADE IN GROUND.		139	5
		C. MAN. REL RR WHL CNTRL. RET'S TO ON/HOLD.	2,4	144	1
3	LOWER TRAILS				
		CONCURRENT OPERATION ON LEFT, RIGHT & REAR:			
		A. MAN. MOVE CANNON LAY FR HOLD TO UP UNTIL TRAILS ON GROUND.	5/6	145	6
		B. TRAILS LOWER TO GROUND.		146	5
		C. MAN. REL CANNON LAY. RET'S TO HOLD.	5/6	151	1
2	EQUILIBRATE BARREL				
		A. MAN. MOVE EQUIL ON/OFF FR OFF TO ON.	8	152	1
		B. BARREL EQUILIBRATES.		153	2
3	ELEVATE BARREL TO APPROX 300 MILS				
		A. MAN. MOVE CANNON LAY FR HOLD TO UP UNTIL AT APPROX 300 MILS.	5/6	155	7
		B. CANNON RAISES TO APPROX 300 MILS, STOPS.		156	6
		C. MAN. MOVE CANNON LAY FR UP TO HOLD.	5/6	162	1
4	RAISE SPEEDSHIFT ASSY				
		A. MAN. REMOVE SS DISK.	SP. SH.	163	5
		B. MAN. PULL SPR-PIN ON SS ASSY.	ASSY	168	5
		C. MAN. SWIVEL SP SH ASSY UP. AUTO LOCKS IN UP POSITION.		173	5
2	RETR BUCKET, SWAB				
		MAN. RETRIEVE BUCKET, SWAB, AND PLACE BY INSIDE LEFT TRAIL.	TRAIL	155	20

SPEEDSHIFT
PROCEDURE

FMC LTMD - DISPLACEMENT PROCEDURE

WHO	WHAT	HOW	WHERE
2	MOVE BARREL TO 0 DEG TRAVERSE	<p>A. MAN. MOVE CANNON LAY CTL FR HOLD TO L/R UNTIL NOTCHES ALIGN ON GIMBAL & PLATFORM.</p> <p>B. BARREL MOVES TO 0 DEG TRAV, OBS NOTCHES.</p> <p>C. MAN. REL CANNON LAY CTRL. RET'S TO HOLD.</p>	5/6 -- 5/6
2	DEPRESS BARREL TO GROUND	<p>A. MAN. MOVE CANNON LAY CTL FR HOLD TO DOWN UNTIL CRADLE RESTS ON GROUND.</p> <p>B. CRADLE RESTS ON GROUND.</p> <p>C. MAN. REL CANNON LAY CTRL. RET'S TO HOLD.</p>	5/6 -- 5/6
1	TURN OFF BARREL EQUILIBRATION	<p>A. MAN. MOVE EQUIL ON/OFF VALVE FR ON TO OFF.</p> <p>B. BARREL EQUILIBRATION TURNED OFF.</p>	--
1	RETRACT CANNON TO TOW POSITION	<p>A. MAN. MOVE CANNON POS-EMPLACE CTRL FR HOLD TO TOW UNTIL BARREL STOPS.</p> <p>B. BARREL RETRACTS, STOPS.</p> <p>C. MAN. REL. CANNON POS-EMPLACE LEVER.</p>	8 -- 8
4	SECURE BARREL TRAVEL LOCKS	<p>A. MAN. PUSH INWARD ON LEFT TRAVEL LOCK LEVER UNTIL STOPS.</p> <p>B. MAN. PUSH INWARD ON RIGHT TRAVEL LOCK LEVER UNTIL STOPS.</p>	8 8
2	RAISE TRAILS	<p>A. MAN. MOVE CANNON LAY CTL FR HOLD TO DOWN UNTIL TRAIL MOVE UP AND STOP.</p> <p>B. TRAILS RAISE AND STOP.</p> <p>C. MAN. REL CANNON LAY CTRL. RET'S TO HOLD.</p>	5/6 -- 5/6
2,3	UNPIN TRAILS FROM PLATFORM	<p>CONCURRENT ON LEFT & RIGHT: MAN. ROTATE BOLT T-HEAD CCW UNTIL LOOSE AND BOLT SPRINGS OUTWARD FROM NUT.</p>	5,6
1,4	PUSH TRAILS INWARD UNTIL TRAILS STOP	<p>CONCURRENT ON LEFT AND RIGHT: MAN. PUSH HORIZ & PERP TO TRAILS AT ENDS & WALK UNTIL TRAILS HITS CRADLE STOPS.</p>	9,10
2	LOWER TRAILS	<p>A. MAN. MOVE CANNON LAY CTRL FROM HOLD TO TOW UNTIL TRAILS LOWER AND STOP.</p> <p>B. TRAILS LOWER AND STOP.</p> <p>C. MAN. REL CANNON LAY CTRL. RET'S TO HOLD.</p>	5/6 -- 5/6

DISPLACEMENT
PROCEDURES

DISPLACEMENT PROCEDURE - CONT'D.

WHO	WHAT	HOW	WHERE
3	LOCK L & R TRAIL TO CRADLE	<p>A. MAN. PUSH ON LEFT PLUNGER PIN WITH THUMB. 9</p> <p>B. MAN. PULL & REMOVE PLUNGER PIN. 9</p> <p>C. MAN. SWIVEL TRAIL LOCK OUT & DOWN. 9</p> <p>D. MAN. REPLACE PLUNGER PIN IN HOLE. 9</p> <p>E. REPEAT ON RIGHT SIDE OF CRADLE. 10</p>	
1,4	LOWER REAR WHEELS	<p>CONCURRENT ON LEFT AND RIGHT:</p> <p>A. MAN. MOVE REAR WHL CONTROL FR ON/HOLD TO DOWN UNTIL SPADE IS OUT OF GROUND. 2,4</p> <p>B. REAR WHLS LOWER, SPADE IS OUT OF GROUND. --</p> <p>C. MAN. REL. REAR WHL CONTROL. RET'S TO ON/HOLD. 2,4</p>	
1,4	LOWER FRONT WHEELS TO LOCK WHL FRAMES	<p>CONCURRENT ON LEFT AND RIGHT:</p> <p>A. MAN. PULL OUTWARD ON FRAME HANDLE. 1,3</p> <p>B. MAN. SWIVEL FRAME UP & HOLD IN POSITION. 1,3</p> <p>C. MAN. MOVE FRT WHL CNTRL FR ON/HOLD TO OFF. 1,3</p> <p>D. FRT WHLS LOWER, FRAME ALIGNS WITH STOP. --</p> <p>E. MAN. RELEASE FRAME HANDLE. (FRAME LOCKS.) 2,4</p> <p>F. MAN. SWIVEL FRAME UP & ALIGN W/ STOP. 2,4</p>	
1,4	LOWER FRONT WHEELS TO SHIFT WEIGHT TO FRONT WHEELS	<p>CONCURRENT ON LEFT AND RIGHT:</p> <p>A. MAN. MOVE RR WHL CNTRL FR ON/HOLD TO UP UNTIL 4 WHLS ON GROUND. 2,4</p> <p>B. RR WHLS RAISE, 4 WHLS ON GROUND. --</p> <p>C. MAN. MOVE RR WHL CNTRL FR UP TO OFF. 2,4</p> <p>D. MAN. MOVE FRT WHL CNTRL FR OFF TO TO DOWN UNTIL REAR WHLS ARE OFF GROUND ABOUT 3 INCHES. 1,3</p> <p>E. FRT WHLS LOWER TO LIFT REAR WHLS OFF GND. --</p> <p>F. MAN. REL. FRT WHL CONTROL. RET'S TO ON/HOLD. 1,3</p>	
1,3,4	RAISE FRONT OF LTND OFF GROUND	<p>CONCURRENT ON LEFT AND RIGHT:</p> <p>MAN. HOLD HANDLES AT TRAIL ENDS, RAISE FRT OF LTND OFF GROUND. 9,10</p>	

DISPLACEMENT
PROCEDURE

DISPLACEMENT PROCEDURE - CONT'D.

WHO	WHAT	HOW	WHERE
2	POSITION, GUIDE TRUCK	DRIVE TRUCK UNTIL PINTLE IS UNDER LUNETTE.	12
1,3,4	LOWER LUNETTE TO PINTLE	CONCURRENT ON LEFT AND RIGHT: MAN. HOLD HANDLES AT TRAIL ENDS, LOWER LUNETTE ONTO PINTLE.	9,10
1,4	SHIFT WT TO ALL FOUR WHEELS	CONCURRENT ON LEFT AND RIGHT: A. MAN. MOVE FRT WHL CNTRL FR ON/HOLD TO OFF. 1,3 B. ALL FOUR WHLS REST ON GROUND.	
3	CLOSE ACCUMULATOR VALVE	MAN. MOVE PUMP CONTROL VALVE FROM ON TO OFF.	5
2	OPEN & ATTACH BRAKE AIR LINES	A. MAN. DISCNCT SERV HOSE ASSY FR DUMMY CPLG. B. MAN. COUPLE EMERG AIR LINE COUPLING. C. MAN. DISCNCT SERV HOSE ASSY FR DUMMY CPLG. D. MAN. COUPLE SERVICE AIR LINE COUPLING. E. MAN. OPEN EMERGENCY AIR LINE CUTOFF COCK. F. MAN. OPEN SERVICE AIR LINE C/O COCK.	10 12 10 12 12 12
1,4	REL FRONT WHEEL MANUAL BRAKES	CONCURRENT ON LEFT AND RIGHT: A. MAN. TAKE BRAKE HANDLES FR CLAMPED POS & PLACE IN SOCKET. B. MAN. PULL UP ON HANDLE UNTIL STOPS. C. MAN. REPLACE HANDLE TO CLAMPED POS.	1,3 1,3 1,3
3	LOCK LUNETTE TO PINTLE	A. MAN. CLOSE TOWING PINTLE LATCH. B. MAN. INSERT PINTLE COTTER PIN.	12 12
2	CNCT. BLACKOUT LIGHT CABLE ASSY TO PRIME MOVER	A. MAN. DISCNCT ASSY FR DUMMY COUPLING. B. MAN. CONNECT P.M. B/O LT CABLE ASSY.	10 10

DISPLACEMENT
PROCEDURE

FMC LTHD COMBINED MISFIRE PROCEDURE TASKS

INCLUDES ALL TASKS FOR:

HOT TUBE, COLD TUBE, WARM TUBE ON HOT DAY, WARM TUBE ON COOL DAY,
HANGFIRE, STICKERS WITH CHARGE 1 AND M107 OR M549 FAMILY, CHARGE 1
OR 2 AND M483 FAMILY, CHARGE 1,2 OR 3 AND M712 PROJECTILE.

THE CONDITIONS DETERMINE WHICH TASKS SHOULD BE PERFORMED.

FOR ALL FAILURES TO FIRE AFTER ACTIVATING THE FIRING MECHANISM:

1. ATTEMPT TO REFIRE
 - A. MANUALLY MOVE LANYARD CONTROL FROM SAFETY TO FIRE.
 - B. REPEAT.
2. WAIT 2 MINUTES (OR EVACUATE IF TUBE IS "HOT").
3. RETURN BARREL TO LOAD POSITION, INSPECT PRIMER.
 - A. MANUALLY MOVE PRIMER LEVER FROM PRIME TO EXTRACT. (PRIMER IS EXTRACTED.)
 - B. MAN. MOVE BREECH POSITION LEVER FROM BATTERY TO LOAD. (BARREL MOVES FROM BATTERY TO LOAD POSITION.)
 - C. MAN. REMOVE PRIMER AUTOLOADER DRUM.
 1. MAN. PULL CAM PLATE OUT UNTIL STOPS.
 2. PUSH IN PLUNGER ON PIN WITH THUMB.
 3. PULL PIN. (HALF-CIRCLE DRUM RETAINER SWINGS DOWN.)
 4. LIFT DRUM OFF RETAINER.
 - D. INSPECT PRIMER.
 1. INSPECT EXPOSED PRIMER TO SEE IF DENTED BY FIRING PIN. IF NOT, FIRING MECHANISM IS FAULTY.
 2. INSPECT PRIMER TO SEE IF FIRED.
IF DENTED BUT PRIMER NOT FIRED, PRIMER IS A DUD. IF PRIMER FIRED, A HANGFIRE HAZARD REMAINS, AND THE CREW SHOULD WAIT AT LEAST 10 MINUTES - MORE IF THE TUBE IS HOT - BEFORE OPENING THE BREECH BLOCK.

MISFIRE
PROCEDURES
TASKS

MISFIRE PROCEDURE TASKS - CONT'D.

TO CLEAR BY FIRING:

4. REPLACE CHARGE (IF FIRED AS A STICKER, OR IF UNSERVICEABLE AS A RESULT OF A HANGFIRE, WETNESS OR HEATING).
 - A. MAN. MOVE BREECH BLOCK LEVER FROM CLOSE TO OPEN. (BREECH OPENS.)
 - B. REMOVE CHARGE (IF NOT A STICKER).
 - C. LOAD FRESH CHARGE (CHARGE 5 OR HIGHER FOR A STICKER).
 - D. MAN. MOVE BREECH BLOCK LEVER FROM OPEN TO CLOSE. (BREECH CLOSES.)
 5. INSTALL PRIMER DRUM, RETURN BARREL TO BATTERY POSITION.
 - A. MAN. REPLACE PRIMER AUTOLOADER DRUM.
 1. REPLACE DRUM INTO RETAINER.
 2. SWIVEL UP DRUM RETAINER, HOLD AND INSERT PLUNGER PIN.
 - B. MAN. MOVE BREECH POSITION LEVER FROM LOAD TO BATTERY. (BARREL MOVES TO BATTERY POSITION.)
 6. LOAD NEW PRIMER.

MAN. MOVE PRIMER LEVER FROM EXTRACT TO SET. (NEW PRIMER POSITIONED.)
 7. FIRE.

MANUALLY MOVE LANYARD CONTROL FROM SAFETY TO FIRE.
- OR: TO CLEAR BY UNLOADING:
4. REMOVE CHARGE.
 - A. MOVE BREECH BLOCK LEVER FROM CLOSE TO OPEN. (BREECH OPENS.)
 - B. REMOVE AND DISPOSE OF CHARGE.
 5. REMOVE PROJECTILE. EITHER:
 - A. REMOVE M107, M483, M549 FAMILY PROJECTILES BY:
 1. ASSEMBLE RAMMING STAFF.
 2. LOWER BARREL TO 0 DEG DE.
 3. INSERT RAMMING STAFF IN MUZZLE.
 4. INSERT PADDING INTO CHAMBER.
 5. MOVE BREECH BLOCK LEVER FROM OPEN TO CLOSE. (BREECH CLOSES.)

MISFIRE
PROCEDURE
TASKS

MISFIRE PROCEDURE TASKS - CONT'D.

6. PUSH PROJECTILE INTO CHAMBER WITH RAMMING STAFF.
7. MOVE BREECH BLOCK LEVER FROM CLOSE TO OPEN. (BREECH OPENS.)
8. REMOVE PADDING.
9. ADVANCE LOAD TRAY BY MOVING RAM CONTROL FROM RETRACT TO CREEP. (LOAD TRAY ADVANCES SLOWLY AND STOPS AT BREECH.)
10. PUSH PROJECTILE INTO LOAD TRAY WITH RAMMING STAFF.
11. REMOVE RAMMING STAFF.
12. UNPIN LOAD TRAY FROM LOAD TRAY LINK.
 - A. PUSH IN PLUNGER ON PIN WITH THUMB.
 - B. PULL PIN.
13. MAN. PUSH LOAD TRAY, PROJECTILE TO BACK-MOST POSITION.
14. REMOVE AND DISPOSE OF PROJECTILE.

OR:

- B. REMOVE NUCLEAR OR COPPERHEAD (M712) PROJECTILE BY:
 1. ASSEMBLE EXTRACTION DEVICE.
 2. LOWER BARREL TO 0 DEG GE.
 3. INSERT EXTRACTOR INTO BREECH.
 4. ATTACH TO PROJECTILE.
 5. EXERT REARWARD FORCE (HYDRAULIC FOR NUCLEAR, RATCHET FOR M712) TO UNSEAT PROJECTILE FROM FORCING CONE.
 6. DETACH EXTRACTOR.
 7. ADVANCE LOAD TRAY BY MOVING RAM CONTROL FROM RETRACT TO CREEP. (LOAD TRAY ADVANCES SLOWLY AND STOPS AT BREECH.)
 8. MANUALLY PULL PROJECTILE INTO LOAD TRAY.
 9. UNPIN LOAD TRAY FROM LOAD TRAY LINK.
 - A. PUSH IN PLUNGER ON PIN WITH THUMB.
 - B. PULL PIN.
 10. MAN. PUSH LOAD TRAY, PROJECTILE TO BACK-MOST POSITION.
 11. REMOVE AND DISPOSE OF PROJECTILE.

OR:

- C. CLEAR WEAPON BECAUSE WEAPON IS "HOT" AND CALL FOR EXPLOSIVE ORDNANCE DIVISION (EDD) TO REMOVE PROJECTILE.

MISFIRE
PROCEDURE
TASKS

DESCRIPTION: Master schedule

STATUS: The LTHD Phase II Design (pg 2) and Hardware (pg 3) master
schedules are current and complete.

AUTHOR: Robert Rathe, Bart Anderson

1110 ASSEMBLY SEQUENCE AND SCHEDULE

	1987	1988
	Jan..Feb..Mar..Apr..May..Jun..Jul..Aug..Sep..Oct..Nov..Dec..Jan..Feb..Mar..Apr..May..Jun..Jul..Aug..Sep..Oct..Nov..Dec..	
..R08..B09..R10..C01..C02..C03..C04..C05..C06..C07..C08..C09..C10..C11..C12..C13..C14..C15..		
Paperwork.....		
Tech data package.....		
Dynamic Analysis Report - Revised		
PHA Report - Revised.....		
Quality Program Plan.....		
Stress Analysis Report.....		
Acceptance Test Plan.....		
Hardware (see Note 1).....		
Gimbal-platform-spade assembly..		
#5710-425		
Cradle assembly to gimbal.....		
#5710-340		
Trail subassembly.....		
#5710-600		
Trail assembly to system.....		
#5710-595		
Struct test, redesign, rework...		
Cut 1000 fr gimbal-platm-spade.		
#5710-275		
Compound actuator subassembly...		
#5710-260		
Alignment: ways to DE/AZ axis...		
#5710-175		
Fire ctrl' (static-struct only)...		
#5710-400		
Hydraulic piping network.....		
#5710-465		
Operational procedures/testing...		
Cannon subassembly.....		
#5710-250		
Cannon assembly into cradle.....		
#5710-240		
Hydraulic system startup & chkol		
#5710-470		
Install PSA muzzle brake.....		
#5710-475		
Load tray and way.....		
#5710-400		
Fire ctrl' & optics completion...		
#5710-625		
Walking beam whls and axles....		
#5710-650		
Walking beams.....		
#5710-675		
Walking beams to trails.....		
#5710-225		
Brake system.....		
#5710-225		
Tailight and wiring.....		
#5710-575		
Speedshift assy.....		
#5710-200		
Basic issue items and container.		
#5710-500		
Maneplates and locations.....		
#5710-500		
Install 1st article muzzle brake		
#5710-500		
Ship to Army test site.....		

Note 1: Material should arrive 1-3 wks early to allow for inspection and problems.

DESCRIPTION: FABRICATION GROUNDWORK

(MAKE-BUY AND SHOP LOADING)

STATUS: A preliminary make/buy decision meeting was held in which the major LTMD parts to be produced in-house were identified. FMC's facilities, equipment and man-power capabilities were compared with the needs of the program. In-house fabrication includes welding and machining titanium parts, machining Al/SiC parts, and the construction of small composite parts.

Manufacturing was in the process of gearing up for LTMD parts to be manufactured in-house. Dedicated cells were being set up in weld, machining and assembly. A limited production cell was also being set up for composites.

AUTHOR: Jim Wallace, J.F. Tousey

LTHD

MAKE

BUY

1ST REVIEW

13 FEB 87

PREPARED BY

J. WALLACE
J. TOUSLEY
M. HASS

LTHO ASSEMBLY SEQUENCE AND SCHEDULE

	1987	1988
	Jan..Feb..Mar..Apr..May..Jun..Jul..Aug..Sep..Oct..Nov..Dec..	Jan..Feb..Mar..Apr..May..Jun..Jul..Aug..Sep..Oct..Nov..Dec..
..R08..B09..R10..C01..C02..C03..C04..C05..C06..C07..C08..C09..C10..C11..C12..C13..C14..C15..		
Paperwork.....		
Tech data package.....		
Dynamic Analysis Report - Revised		
PIHA Report - Revised.....		
Quality Program Plan.....		
Stress Analysis Report.....		
Acceptance Test Plan.....		
Hardware (see Note 1).....		
Gimbal-platform-spade assembly..		
Cradle assembly to gimbal.....		
Trail subassembly.....		
Trail assembly to system.....		
Struct test, redesign, rework..		
Cut 1000 fr gimbal-platfm-spade.		
Compound actuator subassembly...		
Compound actuator assy to cradle		
Alignment: ways to OE/AZ axis...		
Fire ctrl (static-struct only)...		
Hydraulic piping network.....		
Operational procedures/testing..		
Cannon subassembly.....		
Cannon assembly into cradle.....		
Hydraulic system startup & chhot		
Install PSA muzzle brake.....		
Load tray and way.....		
Fire ctrl & optics completion...		
Walking beam whls and axles....		
Walking beams.....		
Walking beams to trails.....		
Brake system.....		
Tailight and wiring.....		
Speedshift assy.....		
Basic issue items and container.		
Maneplates and locations.....		
Install 1st article muzzle brake		
Ship to Army test site.....		

Note 1: Material should arrive 1-3 wks early to allow for inspection and problems.

CONCERNS FOR MANUFACTURING

- NEW DESIGNS - ASSOCIATED PROBLEMS
- SHORT LEAD TIMES
- NEW MATERIALS
 - T1
 - ALSIC
- MIN. CUTTING DATA AVAILABLE
- COOLANT TYPES
- CONTAMINATION
- HEAT TREAT
- PLATING

MANUFACTURING AREA

CELL	1294 HRS	106 PARTS	229 OPERATIONS
OUTSIDE CELL	266 HRS	11 PARTS	22 OPERATIONS
PROCESSES REQ	117		
N/C PROGRAMS	8		
TOOLING REQ	2		

MANUFACTURING CONCERNS

- A. RECTANGULAR TUBE
- B. TOOLING LEAD TIME
- C. MECHANICAL RE-CONTOURING PARTS
- D. FORMING (COLD-HOT)
- E. MATERIAL CONTAMINATION
- F. DESIGN, WELD JOINTS, ACCESSIBILITY

WELD MANUFACTURING

WELD CELL (CLEAN ROOM)	183.0 Hrs.	SET-UP & UNIT
OUTSIDE CELL (WELD SHOP)	658.0 Hrs.	SET-UP & UNIT
PROCESSING	900.0 Hrs.	360 Hrs 2.5/H.
NC PROGRAMS	1088.0 Hrs.	136 TAPES 8.0/Tape
TOOLING		17 FIXTURES
DESIGN	595.0 Hrs.	
Mtg.	1190.0 Hrs.	
ASSEMBLIES (WELD)		9 MAJOR

COMPOSITE AREA

FABRICATION	836 HOURS	46 PCS
MACHINING		
CELL	703 HOURS	179 PCS
NON CELL	188 HOURS	7 PCS
PROCESS REQ	61	
TOOLING	31	

JIM WALLACE
13 FEB

7

AD-A183 982

LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87

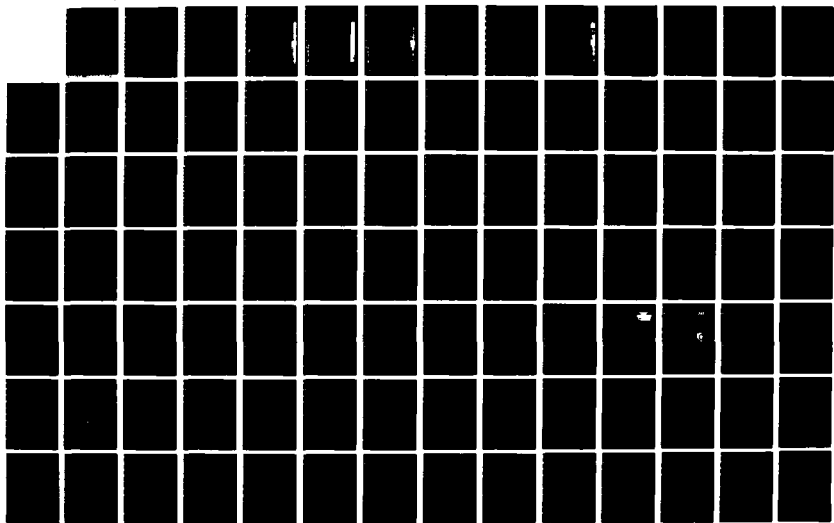
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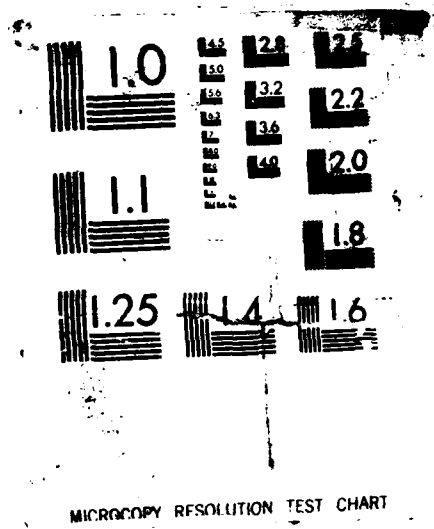
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FMC-E-3041-VOL-A DAAA21-86-C-0047

F/G 19/6

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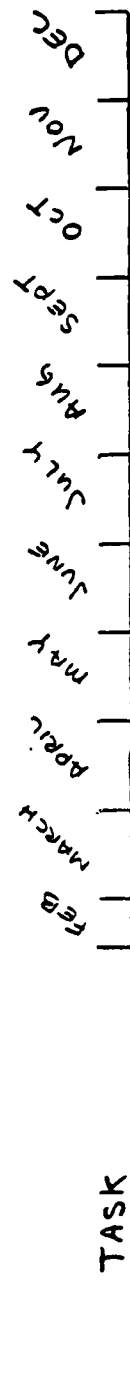




MICROCOPY RESOLUTION TEST CHART

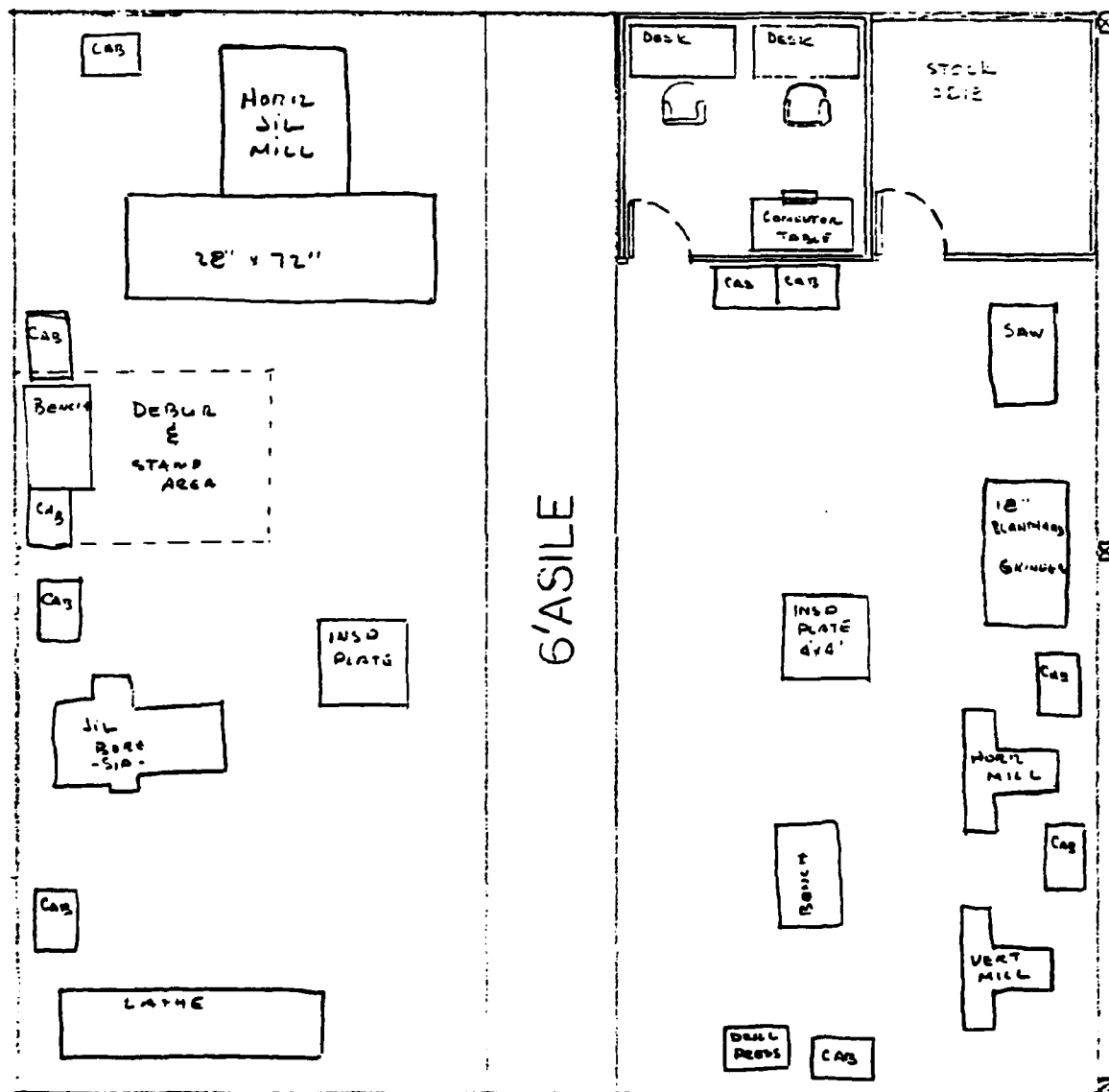
J. WALLACE
13 FEB

LTHD MFGENG PLAN FY 1987



ASSY, MAJOR PARTS
HYD. START UP
FINISH CANNON





2500 SQ.FT.
LTHD CELL

PART NUMBER	1	QTY	REQ	TOOL	QTY	REQ	DATE	TIME	UNIT	TIME	UNIT	TIME
5730	TI	2						4.0	1.80	3.4		
5731	TI	1						19.5	10.5			
5733	TI	1						19.5	12.8			
5736	TI	2						4.0	1.5	4.0		
5741	ALSC	4						4.5	3.0	12.0		
5742	ALSC	4						3.5	1.5	7.2		
5747	ALSC	4						6.5	1.5	19.2		
5748	ALSC	4						3.5	1.5	6.0		
5753	ALSC	8						2.5	2.5	12.0		
5760	TI	2						4.5	2.0	4.0		
5761	TI	2						3.5	1.5	3.0		
5762	TI	2						3.0	1.5	3.0		
5763	COMP	1						1.5	1.5			
5764	TI	3						3.0	2.5	4.5		
5771	TI	1						3.0	2.5			
5774	TI	1						3.0	2.5			
5775	TI	1						3.0	2.5			
5776	TI	1						3.0	2.5			
5777	TI	1						1.5	2.0			
5779	COMP	1						1.5	1.5			
5780	COMP	1						1.5	1.7			
5781	ALSC	1						2.5	2.7			
5781-2	ALSC	2						4.5	1.7	3.4		
5781-3	ALSC	2						4.5	1.7	3.4		
5781-4	ALSC	2						6.5	1.7	3.4		
5781-5	ALSC	2						4.5	1.7	3.4		
5782	TI	10						5.0	1.4	14.0		
5782	COMP	1						2.5	1.7			
5782	TI	1						9.5	3.5			
5783	TI	1						9.5	2.8			
5783	TI	1						8.0	12.0			
5783	TI	1						4.5	2.5	5.0		
5783	TI	1						4.4	2.0			
5783	TI	1						1.0	2.0			
5783	TI	1						1.0	2.5			
5783	TI	1						1.0	2.5			
5783	TI	1						2.5	2.5			
5783	TI	1						15.0	15.0			
5783	TI	1						3.5	1.2	2.4		
5783	TI	1						3.5	2.0			
5783	TI	1						4.4	1.5	1.2		
5783	TI	1						4.4	1.5	1.2		

PART NUMBER	QTY	TOOL REQ	UNIT TIME	TIME	TIME
5921 STP	1	X	1.5	1.0	4.0
5924 CFE	1	X	2.0	2.5	
5925 CFE	1	X	5.5	2.5	
5926 CFE	1	X	4.5	2.0	
5927 CFE	1	X	2.5	2.5	
5928 CFE	1	X	2.5	1.7	3.4
5929 CFE	1	X	3.5	2.0	
5930 CFE	1	X	5.0	3.0	
5931 CFE	2	X	2.0	1.5	3.0
5932 CFE	2	X	2.0	1.5	3.0
5933-1 ALSC	4	X	3.5	1.5	2.0
5933-2 ALSC	4	X	1.5	2.0	
5934-1 ALSC	4	X	1.5	2.0	
5934-2 ALSC	4	X	1.5	2.0	
5935-1 ALSC	4	X	1.5	2.0	
5935-2 ALSC	4	X	1.5	2.0	
5936-1 ALSC	4	X	1.5	2.0	
5936-2 ALSC	4	X	1.5	2.0	
5937-1 ALSC	4	X	1.5	2.0	
5937-2 ALSC	4	X	1.5	2.0	
5938-1 ALSC	4	X	1.5	2.0	
5938-2 ALSC	4	X	1.5	2.0	
5939-1 ALSC	4	X	1.5	2.0	
5939-2 ALSC	4	X	1.5	2.0	
5940-1 ALSC	4	X	1.5	2.0	
5940-2 ALSC	4	X	1.5	2.0	
5941-1 ALSC	4	X	1.5	2.0	
5941-2 ALSC	4	X	1.5	2.0	
5942-1 ALSC	4	X	1.5	2.0	
5942-2 ALSC	4	X	1.5	2.0	
5943-1 ALSC	4	X	1.5	2.0	
5943-2 ALSC	4	X	1.5	2.0	
5944-1 ALSC	4	X	1.5	2.0	
5944-2 ALSC	4	X	1.5	2.0	
5945-1 ALSC	4	X	1.5	2.0	
5945-2 ALSC	4	X	1.5	2.0	
5946-1 ALSC	4	X	1.5	2.0	
5946-2 ALSC	4	X	1.5	2.0	
5947-1 ALSC	4	X	1.5	2.0	
5947-2 ALSC	4	X	1.5	2.0	
5948-1 ALSC	4	X	1.5	2.0	
5948-2 ALSC	4	X	1.5	2.0	
5949-1 ALSC	4	X	1.5	2.0	
5949-2 ALSC	4	X	1.5	2.0	
5950-1 ALSC	4	X	1.5	2.0	
5950-2 ALSC	4	X	1.5	2.0	
5951-1 ALSC	4	X	1.5	2.0	
5951-2 ALSC	4	X	1.5	2.0	
5952-1 ALSC	4	X	1.5	2.0	
5952-2 ALSC	4	X	1.5	2.0	
5953-1 ALSC	4	X	1.5	2.0	
5953-2 ALSC	4	X	1.5	2.0	
5954-1 ALSC	4	X	1.5	2.0	
5954-2 ALSC	4	X	1.5	2.0	
5955-1 ALSC	4	X	1.5	2.0	
5955-2 ALSC	4	X	1.5	2.0	
5956-1 ALSC	4	X	1.5	2.0	
5956-2 ALSC	4	X	1.5	2.0	
5957-1 ALSC	4	X	1.5	2.0	
5957-2 ALSC	4	X	1.5	2.0	
5958-1 ALSC	4	X	1.5	2.0	
5958-2 ALSC	4	X	1.5	2.0	
5959-1 ALSC	4	X	1.5	2.0	
5959-2 ALSC	4	X	1.5	2.0	
5960-1 ALSC	4	X	1.5	2.0	
5960-2 ALSC	4	X	1.5	2.0	
5961-1 ALSC	4	X	1.5	2.0	
5961-2 ALSC	4	X	1.5	2.0	
5962-1 ALSC	4	X	1.5	2.0	
5962-2 ALSC	4	X	1.5	2.0	
5963-1 ALSC	4	X	1.5	2.0	
5963-2 ALSC	4	X	1.5	2.0	
5964-1 ALSC	4	X	1.5	2.0	
5964-2 ALSC	4	X	1.5	2.0	
5965-1 ALSC	4	X	1.5	2.0	
5965-2 ALSC	4	X	1.5	2.0	
5966-1 ALSC	4	X	1.5	2.0	
5966-2 ALSC	4	X	1.5	2.0	
5967-1 ALSC	4	X	1.5	2.0	
5967-2 ALSC	4	X	1.5	2.0	
5968-1 ALSC	4	X	1.5	2.0	
5968-2 ALSC	4	X	1.5	2.0	
5969-1 ALSC	4	X	1.5	2.0	
5969-2 ALSC	4	X	1.5	2.0	
5970-1 ALSC	4	X	1.5	2.0	
5970-2 ALSC	4	X	1.5	2.0	
5971-1 ALSC	4	X	1.5	2.0	
5971-2 ALSC	4	X	1.5	2.0	
5972-1 ALSC	4	X	1.5	2.0	
5972-2 ALSC	4	X	1.5	2.0	
5973-1 ALSC	4	X	1.5	2.0	
5973-2 ALSC	4	X	1.5	2.0	
5974-1 ALSC	4	X	1.5	2.0	
5974-2 ALSC	4	X	1.5	2.0	
5975-1 ALSC	4	X	1.5	2.0	
5975-2 ALSC	4	X	1.5	2.0	
5976-1 ALSC	4	X	1.5	2.0	
5976-2 ALSC	4	X	1.5	2.0	
5977-1 ALSC	4	X	1.5	2.0	
5977-2 ALSC	4	X	1.5	2.0	
5978-1 ALSC	4	X	1.5	2.0	
5978-2 ALSC	4	X	1.5	2.0	
5979-1 ALSC	4	X	1.5	2.0	
5979-2 ALSC	4	X	1.5	2.0	
5980-1 ALSC	4	X	1.5	2.0	
5980-2 ALSC	4	X	1.5	2.0	
5981-1 ALSC	4	X	1.5	2.0	
5981-2 ALSC	4	X	1.5	2.0	
5982-1 ALSC	4	X	1.5	2.0	
5982-2 ALSC	4	X	1.5	2.0	
5983-1 ALSC	4	X	1.5	2.0	
5983-2 ALSC	4	X	1.5	2.0	
5984-1 ALSC	4	X	1.5	2.0	
5984-2 ALSC	4	X	1.5	2.0	
5985-1 ALSC	4	X	1.5	2.0	
5985-2 ALSC	4	X	1.5	2.0	
5986-1 ALSC	4	X	1.5	2.0	
5986-2 ALSC	4	X	1.5	2.0	
5987-1 ALSC	4	X	1.5	2.0	
5987-2 ALSC	4	X	1.5	2.0	
5988-1 ALSC	4	X	1.5	2.0	
5988-2 ALSC	4	X	1.5	2.0	
5989-1 ALSC	4	X	1.5	2.0	
5989-2 ALSC	4	X	1.5	2.0	
5990-1 ALSC	4	X	1.5	2.0	
5990-2 ALSC	4	X	1.5	2.0	
5991-1 ALSC	4	X	1.5	2.0	
5991-2 ALSC	4	X	1.5	2.0	
5992-1 ALSC	4	X	1.5	2.0	
5992-2 ALSC	4	X	1.5	2.0	
5993-1 ALSC	4	X	1.5	2.0	
5993-2 ALSC	4	X	1.5	2.0	
5994-1 ALSC	4	X	1.5	2.0	
5994-2 ALSC	4	X	1.5	2.0	
5995-1 ALSC	4	X	1.5	2.0	
5995-2 ALSC	4	X	1.5	2.0	
5996-1 ALSC	4	X	1.5	2.0	
5996-2 ALSC	4	X	1.5	2.0	
5997-1 ALSC	4	X	1.5	2.0	
5997-2 ALSC	4	X	1.5	2.0	
5998-1 ALSC	4	X	1.5	2.0	
5998-2 ALSC	4	X	1.5	2.0	
5999-1 ALSC	4	X	1.5	2.0	
5999-2 ALSC	4	X	1.5	2.0	
6000-1 ALSC	4	X	1.5	2.0	
6000-2 ALSC	4	X	1.5	2.0	

PART NUMBER	M	QTY	REQ.	TOOL	UNIT	TIME	UNIT	TIME	LINE
5821	TI	1				2.5	1.5	3.0	
5822	ALUM	2				7.5	2.5	4.4	
5823	"	2				4.0	2.2	5.4	
5824	Comp	2				4.5	2.7	6.0	
5825	Comp	4				4.5	3.0	14.0	
5826	Comp	2				3.0	2.5	5.0	
5827	Comp	1				2.5	2.5	28.0	
5828	TI	44				22.0	2.5	1.5	28.0
5829	TI	40				1.5	1.5	1.8	13.0
5830	ALUM	16				2.5	1.8	1.3	14.8
5831	"	56				3.0	1.5	24.0	
5832	Comp	2				2.0	1.5	2.0	
5833	TI	3				3.0	2.0	4.0	
5834	Plastic	4				5.0	2.5	10.0	
5835	ALUM	4				5.0	2.5	10.0	
5836	ALUM	4				4.5	3.0	12.0	
5837	Comp	1				4.5	4.0	8.0	
5838	Comp	1				4.5	4.0	8.0	
5839	Comp	1				3.0	2.5	3.0	
5840	NYLO	3				4.0	2.0	3.0	
5841	Comp	1				4.0	2.0	3.0	
5842	NYLO	2				4.5	1.0	2.0	
5843	ALUM	2				4.5	2.5	3.0	
5844	ALSC	2				4.5	1.5	3.0	
5845	ALUM	1				4.5	1.0	2.0	
5846	ALUM	1				4.5	2.0	4.0	
5847	Comp	1				3.0	4.0	5.0	1.5
5848	NYLO	4				5.0	1.5	6.0	
5849	Comp	1				4.5	3.5	4.0	3.0
5850	NYLO	1				4.0	3.0	4.0	2.5
5851	Comp	1				4.0	2.5	4.0	2.0
5852	TI	1				4.5	2.5	2.5	2.5
5853	Comp	3				6.0	2.5	2.5	1.0
5854	ALUM	10				4.5	1.0	6.0	4.0
5855	TI	4				4.0	1.5	6.0	4.0
5856	TI	4				4.0	1.5	6.0	4.0
5857	TI	4				4.0	1.5	6.0	4.0
5858	TI	4				4.0	1.5	6.0	4.0
5859	TI	4				4.0	1.5	6.0	4.0

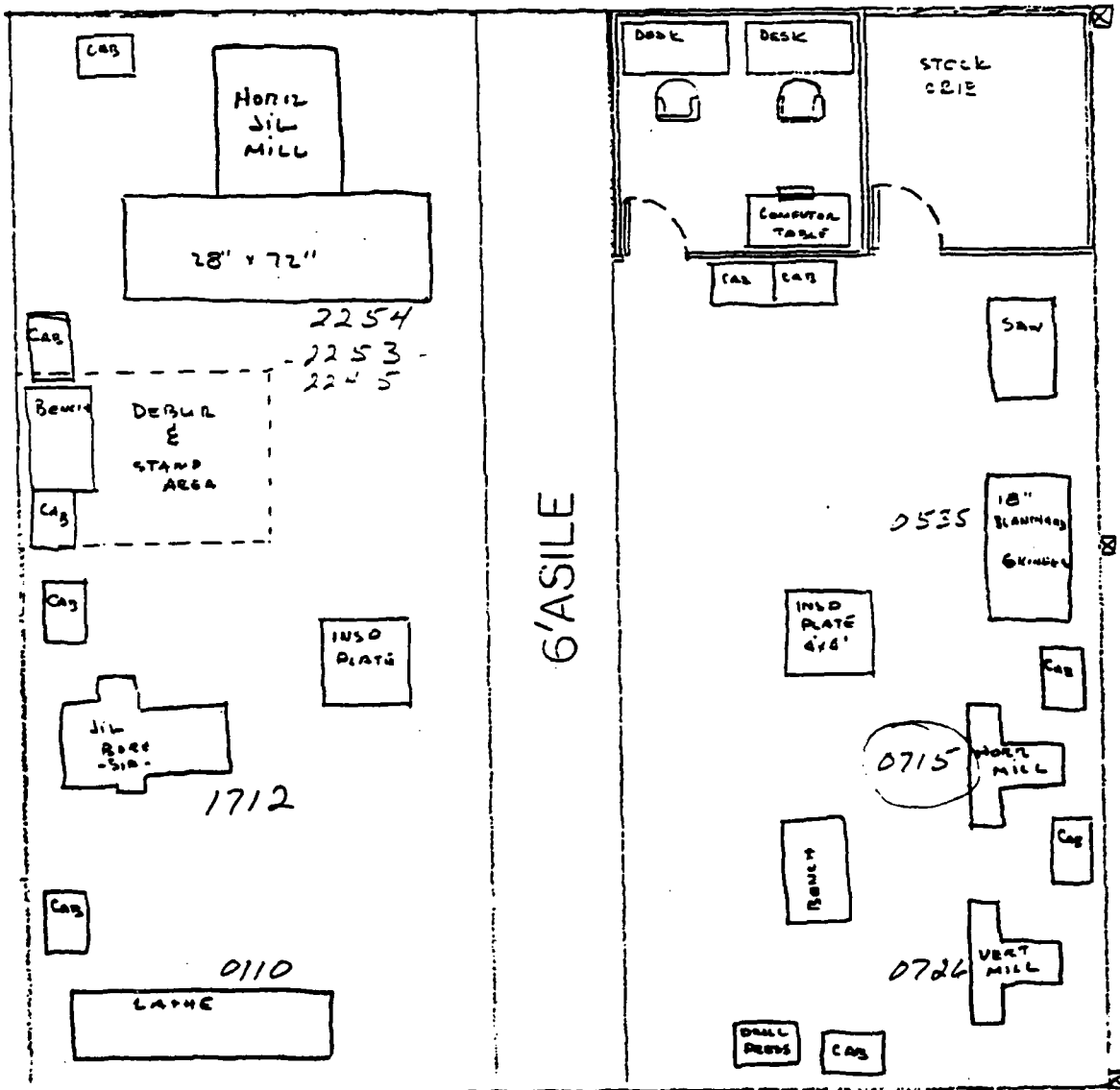
299

Long

75
74

Long Thomas 7112 work beds -

14



2500 SQ.FT.
LTHD CELL

**REQUEST FOR FACILITY
DEPARTMENT SERVICES**

Requestor G.D. LANNUE		Extension 7211	Department WELD	Date 2-26-87
		Account Number AR507-1-0000		

DESCRIPTION

In support of the new Weld Clean Room, the Lightweight Towed Howitzer Program requires ^{SIX} FIVE bays in the Weld Dept for a Machine shop area and a Weld-layout, NDT and Cleanup area for building the prototype LWTH. This proposed area should be washed down, painted, Floor sealed, Chain link fenced, have amber drop curtain from ceiling to floor wall effect to keep clean and reduce noise level and contain electrical power for machines and welders.

Location West 16th Posts 5 thru 9 1/2 SW, E Post 11 1/2 T. 13 Existing lights, air and Sibs can be used.				
Budgeted <input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> AFE <input type="checkbox"/> R&R <input type="checkbox"/> Other	Amount Budgeted \$	Cost Limit \$	AFE Budget Number

SPECIAL CONSIDERATIONS:

<input type="checkbox"/> Space Planning/Layout	<input checked="" type="checkbox"/> Estimate Required; Date ASAP
<input type="checkbox"/> Shop	<input type="checkbox"/> Equipment Installation
<input type="checkbox"/> Office	<input type="checkbox"/> Foundation
Utilities Required	<input type="checkbox"/> Telephone
<input type="checkbox"/> Electrical	<input type="checkbox"/> Quantity _____
<input type="checkbox"/> Air	<input type="checkbox"/> Type _____
<input type="checkbox"/> Water	<input type="checkbox"/> Name Plate(s); Name(s) _____
<input type="checkbox"/> Other _____	
<input type="checkbox"/> Terminal Cabling _____	

Furniture Required

Equipment Delivery Date

Operational Requirement Date

Executive Approval

Date

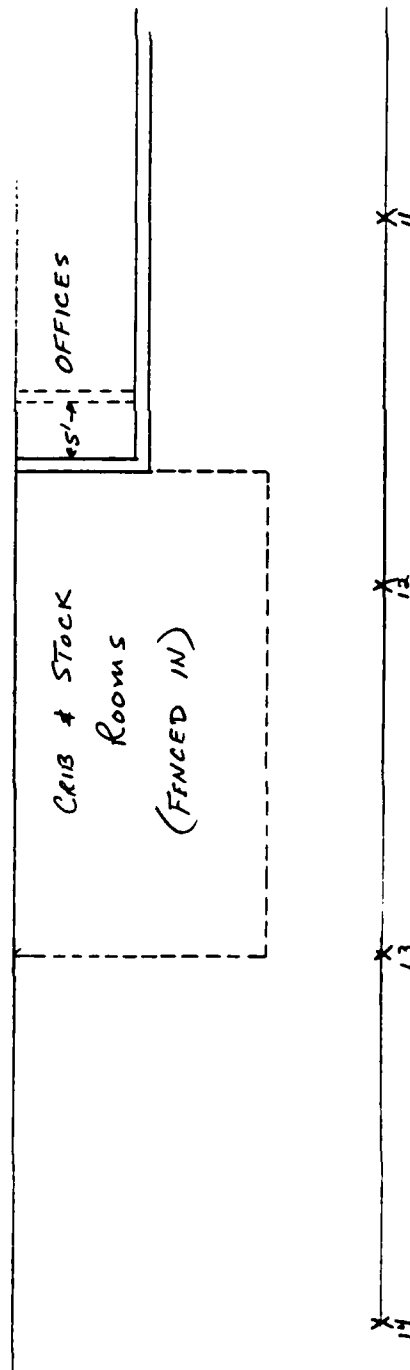
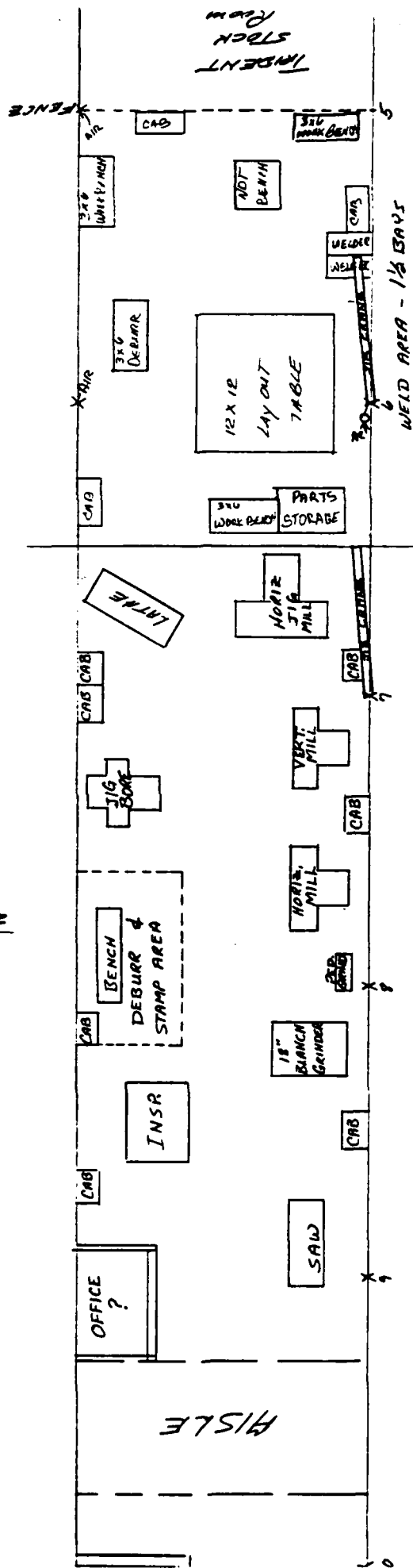
FACILITY DEPARTMENT ACTION

Assigned To	Extension
Action	

DISTRIBUTION:

<input type="checkbox"/> Facility Dept.	<input type="checkbox"/> Requestor	<input type="checkbox"/> Office Services	<input type="checkbox"/> Office Repair
<input type="checkbox"/> Office Info. Services	<input type="checkbox"/> MIS	<input type="checkbox"/> Data Center/Network Control Center	

Facility Department Approval



DESCRIPTION: PHASE II SCHEDULE

STATUS: A schedule for the completion of Phase II was developed based on estimates of completion from all individuals working on the project. The schedule is current and complete.

AUTHOR: Bart Anderson, Dave Boudreau and Scott Dacko

10

P

P

F

[illegible]

PROJECT: LTHD REMAINING PHASE II

FILE: PHASE2

		March 1987				April 1987				May 1987				June 1987					
L	REMAINING PHASE II	Hrs	Who	12	9	16	23	30	16	13	20	27	14	11	18	25	11	8	
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----																			
	SYSTEMS ENGRG	13100	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	SYSTEMS ENGRG	350231 31011,21,31,41	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	OPP,REL,TEST,SPECS,PHA		:	323:SY	-----									
	PROJECT MANAGEMENT	13200	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	MECHANICAL ENGRG	350232 31031	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	PROJECT COORDINATION		:	200:ME	-----									
	PROJECT MANAGEMENT	350232 31011	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	PROJ MANAGEMENT		:	80:PM	-----									
	TRAVEL MOD/CEL	350232 31021	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	TRAVEL		:	0:IX	-----									
	MODEL		:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	MODEL MAKING		:	0:IX	-----									
	DATA PREPARATION	14100	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	MECHANICAL ENGRG	350241 31011	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	COMPILE REPORTS		:	44B:ME	-----									
	GFE SUPPORT	15100	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	MECHANICAL ENGRG	350251 31011	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	GFE COORDINATION		:	46:ME	-----									
	SPARE PARTS	15400	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	MECHANICAL ENGRG	350254 31011	:	:	:	.	.	.	.	.	.	.	.	.	.	.	.	.
	COMPILE PARTS LIST		:	90:ME	-----									

MAR 02 87

PAGE 3

PROJECT: LTHD REMAINING PHASE II

FILE: PHASE2

L	EMAINING PHASE II	March 1987					April 1987					May 1987					June 1987				
		Hrs	Who	12	9	16	23	30	16	13	20	27	14	11	18	25	11	8			
=====																					

RESOURCE SUMMARY

MANUFACTURING ENGR	521	MF	67	67	67	67	67	67	67	67	65							
MECHANICAL ENGR	521	ME	904	904	904	936	936	964	891	830	708	190	4					
CEL	401	CE																
ANALYTICAL ENGR	521	AE	121	121	121	121	109	92	92	92	92	92						
COMPOSITE ENGR	521	OC	78	78	78	78	78	78	78	78	62							
YORK PERSONNEL	401	YO																
QUALITY ENGR	521	QA	9	9	9	9	9	9	9	9	9							
TEST ENGR	521	TE	12	12	12	12	12	12	11									
SYSTEMS ENGR	521	SY	36	36	36	36	36	36	36	36	35							
PROJ MANAGER	481	PM	8	8	8	8	8	8	8	8	8	8						
UNASSIGNED	01	IX																
TOTAL HOURS			1234	1234	1233	1266	1254	1265	1192	1119	979	290	4					

MAR 02 87 ACTIVITY STATUS - ACTUAL VS PLAN
PROJECT: LTHD REMAINING PHASE II

PAGE 1
FILE: PHASE2

Status	CP	----- Start -----		----- End -----		Who	----- Work Effort (Hrs) -----				
		Planned	Rev/act	Planned	Rev/act		Actual (+) To-Date	Fcst (=) To-Cap	Latest (vs) Estimate	Orig (=) Plan	Ahead (Behind)

P010 FINAL ASSEMBLY
11100

A010 ADV-MFG METAL
350213 31091

T040	MANUFACTURING REVIEW	3-02-87		5-01-87		MF	0	400	400	400	0
------	----------------------	---------	--	---------	--	----	---	-----	-----	-----	---

A020 MECHANICAL ENGRG
350211 31011

T040	STABILITY ANALYSIS	4-13-87		4-29-87		ME	0	70	70	70	0
------	--------------------	---------	--	---------	--	----	---	----	----	----	---

T080	ASSEMBLY DRWG PREPARATION	3-02-87		5-01-87		ME	0	817	817	817	0
------	---------------------------	---------	--	---------	--	----	---	-----	-----	-----	---

T120	UPDATE TDF	3-02-87		5-01-87		ME	0	484	484	484	0
------	------------	---------	--	---------	--	----	---	-----	-----	-----	---

T160	LONG LEAD ITEMS	3-02-87		4-15-87		ME	0	60	60	60	0
------	-----------------	---------	--	---------	--	----	---	----	----	----	---

P020 CANNON
11200

A010 MECHANICAL ENGRG
350212 31011

T040	DRWG PREPARATION	3-02-87		3-20-87		ME	0	128	128	128	0
------	------------------	---------	--	---------	--	----	---	-----	-----	-----	---

P030 CARRIAGE
11300

A010 ADV MFG-ORGANIC COMPOSITE
350213 31071

T040	MFG REVIEW OF COMPOSITES	3-02-87		5-01-87		MF	0	200	200	200	0
------	--------------------------	---------	--	---------	--	----	---	-----	-----	-----	---

MAR 02 87 ACTIVITY STATUS - ACTUAL VS PLAN
PROJECT: LTHD REMAINING PHASE II

PAGE 2
FILE: PHASE2

		----- Start -----		----- End -----		----- Work Effort (Hrs) -----					
Status	CP	Planned	Rev/act	Planned	Rev/act	Who	Actual (+) To-Date	Fcst (=) To-Cmpl	Latest (vs) Estimate	Orig (=) Plan	Ahead (Behind)
A020	CEL-STRUCTURAL ANALYSIS										
	350211 31031										
T040	CEL/RODAMACHER	3-02-87		4-15-87		CE	0	0	0	0	0
A030	MECHANICAL ENGRG										
	350213 31031										
T040	MANIFOLD/HL DESIGN	3-02-87		4-06-87		ME	0	647	647	647	0
T080	MANIFOLD/HL DRWG PREP	3-02-87		5-08-87		ME	0	567	567	567	0
T120	HYDRAULIC SYS DESIGN	3-02-87		4-30-87		ME	0	493	493	493	0
T160	HYDRAULIC SYS DRWG PREP	3-02-87		5-08-87		ME	0	430	430	430	0
T200	LOAD TRAY & WAY DRWG PREP	3-02-87		5-01-87		ME	0	646	646	646	0
T240	TRAIL DESIGN	3-02-87		4-30-87		ME	0	180	180	180	0
T280	TRAIL DRWG PREP	3-02-87		5-08-87		ME	0	586	586	586	0
T320	PLAT,6INB,SPADE DESIGN	3-02-87		4-10-87		ME	0	192	192	192	0
T360	PLAT,6INB,SPADE DRWG PREP	3-02-87		4-24-87		ME	0	591	591	591	0
T400	CRADLE DESIGN	3-02-87		4-30-87		ME	0	120	120	120	0

MAR 02 87 ACTIVITY STATUS - ACTUAL VS PLAN
PROJECT: LTHD REMAINING PHASE II

PAGE 4
FILE: PHASE2

Status	CP	----- Start -----		----- End -----		Who	----- Work Effort (Hrs) -----				
		Planned	Rev/act	Planned	Rev/act		Actual (+) To-Date	Fcst (=) To-Cmpl	Latest (vs) Estimate	Orig (=) Plan	Ahead (Behind)

T040	FIRE CONTROL DRWG PREP		3-23-87		5-01-87	ME	0	449	449	449	0
------	------------------------	--	---------	--	---------	----	---	-----	-----	-----	---

P050 QA/QC/TEST
12100

A010 QUALITY ASSURANCE
350211 31021

T040	QUALITY PROGRAM PLAN		3-02-87		5-01-87	QA	0	80	80	80	0
------	----------------------	--	---------	--	---------	----	---	----	----	----	---

P060 ACCEPTANCE TEST
12200

A010 TEST
350222 31011

T040	ID TEST VENDOR		3-02-87		4-17-87	TE	0	81	81	81	0
------	----------------	--	---------	--	---------	----	---	----	----	----	---

F TEST EXPENSE
12300

A010 TEST COMPOSITES

T040	SUPPORT COMPOSITE TEST		3-02-87		4-30-87	ME	0	150	150	150	0
------	------------------------	--	---------	--	---------	----	---	-----	-----	-----	---

P080 SYSTEMS ENGRG
13100

A010 SYSTEMS ENGRG
350231 31011,21,31,41

T040	BPP,REL,TEST,SPECS,PHA		3-02-87		5-01-87	SY	0	323	323	323	0
------	------------------------	--	---------	--	---------	----	---	-----	-----	-----	---

P090 PROJECT MANAGEMENT
13200

A010 MECHANICAL ENGRG
350232 31031

T	PROJECT COORDINATION		3-02-87		5-11-87	ME	0	200	200	200	0
---	----------------------	--	---------	--	---------	----	---	-----	-----	-----	---

Status	CP	----- Start -----		----- End -----		Who	----- Work Effort (Hrs) -----				
		Planned	Rev/act	Planned	Rev/act		Actual (+) To-Date	Fcst (=) To-Cmpl	Latest (vs) Estimate	Orig (=) Plan	Ahead (Behind)

A020 PROJECT MANAGEMENT
350232 31011

T040	PROJ MANAGEMENT	3-02-87		5-11-87		PM	0	80	80	80	0
------	-----------------	---------	--	---------	--	----	---	----	----	----	---

A030 TRAVEL MOD/CEL
350232 31021

T040	TRAVEL	3-02-87		3-02-87		X	0	0	0	0	0
------	--------	---------	--	---------	--	---	---	---	---	---	---

A040 MODEL

T040	MODEL MAKING	3-02-87		3-31-87		X	0	0	0	0	0
------	--------------	---------	--	---------	--	---	---	---	---	---	---

P100 DATA PREPARATION
14100

A1 MECHANICAL ENGRG
350241 31011

T040	COMPILE REPORTS	4-06-87		5-01-87		ME	0	448	448	448	0
------	-----------------	---------	--	---------	--	----	---	-----	-----	-----	---

P110 GFE SUPPORT
15100

A010 MECHANICAL ENGRG
350251 31011

T040	GFE COORDINATION	4-06-87		4-24-87		ME	0	46	46	46	0
------	------------------	---------	--	---------	--	----	---	----	----	----	---

P120 SPARE PARTS
15400

A010 MECHANICAL ENGRG
350254 31011

T040	COMPILE PARTS LIST	3-02-87		5-01-87		ME	0	90	90	90	0
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ACTIVITY STATUS - ACTUAL VS PLAN

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PROJECT: LTHD REMAINING PHASE II

FILE: PHASE2

		----- Start -----		----- End -----		----- Work Effort (Hrs) -----					
Status	CP	Planned	Rev/act	Planned	Rev/act	Who	Actual (+) To-Date	Fcst (=) To-Capl	Latest (vs) Estimate	Orig (=) Plan	Ahead (Behind)
TOTAL PROJECT		3-02-87		5-11-87		ALL	0	11,079	11,079	11,079	0

		----- Start -----		----- End -----		----- Work Effort (Hrs) -----					
Status	CP	Planned	Rev/act	Planned	Rev/act	Who	Actual (+) To-Date	Fcst (=) To-Copl	Latest (vs) Estimate	Orig (=) Plan	Ahead (Behind)

REL. SPACE SUMMARY

MANUFACTURING ENGR	MF	0	600	600	600	0
MECHANICAL ENGR	ME	0	8,176	8,176	8,176	0
CEL	CE	0	0	0	0	0
ANALYTICAL ENGR	AE	0	1,055	1,055	1,055	0
COMPOSITE ENGR	OC	0	684	684	684	0
YORK PERSONNEL	YO	0	0	0	0	0
QUALITY ENGR	QA	0	80	80	80	0
TEST ENGR	TE	0	81	81	81	0
SYSTEMS ENGR	SY	0	323	323	323	0
PROJ MANAGER	PM	0	80	80	80	0
UNASSIGNED	X	0	0	0	0	0

TOTAL PROJECT		3-02-87	5-11-87	ALL	0	11,079	11,079	11,079	0
---------------	--	---------	---------	-----	---	--------	--------	--------	---

DESCRIPTION: LONG LEAD ITEM SCHEDULE

STATUS: A schedule of long lead items was developed from cost and lead time information from vendors supplying long lead time parts.

The schedule is current and complete.

AUTHORS: Bart Anderson, Dave Boudreau and Scott Dacko

FMC LTND
LONG LEAD ITEM SCHEDULE

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

FILE: LTHDLL

			1987												1988				
L1	JNG LEAD ITEMS/SCHDL	Hr	Who	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	INCOMING/IMPROCESS INSP			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHIP TRAIL BULKHD/FITTING			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	WHEEL BULKHEAD 5846			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	DETAILING	0	X	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	MATERIAL PROCUREMENT	0	X	.	.	.	.	...	.	.	.	.	.	.	.	.	.	.	.
	FABRICATING & WELDING	0	X	.	.	.	.	.	.....	.	.	.	.	.	.	.	.	.	.
	MACHINING	0	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	SHIP	0	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	GIMBAL/PLAT/SPADE ASSY 5710-425			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	GIMBAL 5811			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	DETAILING	0	X	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	MATERIAL PROCUREMENT	0	X	.	.	.	.	...	.	.	.	.	.	.	.	.	.	.	.
	FABRICATING & WELDING	0	X	.	.	.	.	.	.....	.	.	.	.	.	.	.	.	.	.
	MACHINING	0	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ASSEMBLY	0	X	.	.	.	.	.	.	.	.	.	...	.	.	.	.	.	.
	PLATFORM 5801			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	DETAILING	0	X	.	....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	MATERIAL PROCUREMENT	0	X	.	.	...	.	.	.	.	.	.	.	.	.	.	.	.	.
	FABRICATING & WELDING	0	X	.	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.
	MACHINING	0	X	.	.	.	.	.	..	.	.	.	.	.	.	.	.	.	.
	ASSEMBLY	0	X	.	.	.	.	.	.	.	.	.	...	.	.	.	.	.	.
	SPADE 5821			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	DETAILING	0	X	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	MATERIAL PROCUREMENT	0	X	.	.	.	.	.	.	...	.	.	.	.	.	.	.	.	.
	FABRICATING & WELDING	0	X	.	.	.	.	.	.	.	.	...	.	.	.	.	.	.	.
	MACHINING	0	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ASSEMBLY	0	X	.	.	.	.	.	.	.	.	.	...	.	.	.	.	.	.
	BOLTING			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	MATERIAL PROCUREMENT	0	X	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	ASSY LD FTNGS TO CRADLE			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	CRADLE 5831			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	DETAILING	0	X	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TOOLING	0	X	.	.	.	.....	.	.	.	.	.	.	.	.	.	.	.	.
	MATERIAL PROCUREMENT	0	X	.	.	.	.....	.	.	.	.	.	.	.	.	.	.	.	.
	FABRICATING	0	X	.	.	.	.	.....	.	.	.	.	.	.	.	.	.	.	.
	MACHINING	0	X	.	.	.	.	.	.	.	.	...	.	.	.	.	.	.	.
	ASSEMBLY	0	X	.	.	.	.	.	.	.	.	.	...	.	.	.	.	.	.
	FRONT CRADLE MANIFOLD 5944			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	DETAILING	0	X	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	MATERIAL PROCUREMENT	0	X	.	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.
	MACHINING	0	X	.	.	.	.	.	.	.....	.	.	.	.	.	.	.	.	.
	ASSEMBLY	0	X	.	.	.	.	.	.	.	.	.	...	.	.	.	.	.	.
	STR TEST,RETEST GPSA			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	PROCURE TEST SITE	0	X	.	.....	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TEST-RETEST	0	X	.	.	.	.	.	.	.	.	.	.....	.	.	.	.	.	.
	STR TEST,RETEST CRADLE			.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	TEST-RETEST	0	X	.	.	.	.	.	.	.	.	.	.....	.	.	.	.	.	.
	COMPOUND ACTUATOR ASSY 5710-275		
	REC'D CYLINDERS 5945,46,75		
	ILING	0	X
	TOOLING	0	X

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

FILE: LTHDLL

			1987												1988				
LT	NS LEAD ITEMS/SCHDL	Hr	Who	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	MATERIAL PROCUREMENT		0 X					XXXX											
	EXTRUDING		0 X							XX									
	MACHINING		0 X							XXXXXXXX									
	ASSEMBLY		0 X									XXXXXXXXXX							
	RECOIL RODS	5949,50																	
	DETAILING		0 X	XXXXXXXXXX															
	TOOLING		0 X					XXXXXXXXXX											
	MATERIAL PROCUREMENT		0 X					XXXX											
	EXTRUDING		0 X							XX									
	MACHINING		0 X							XXXXXXXX									
	ASSEMBLY		0 X									XXXXXXXXXX							
	END CAPS	5951,52																	
	DETAILING		0 X	XXXXXXXXXX															
	TOOLING		0 X					XXXXXXXXXX											
	MATERIAL PROCUREMENT		0 X					XXXX											
	EXTRUDING		0 X							XX									
	MACHINING		0 X							XXXXXXXX									
	ASSEMBLY		0 X									XXXXXXXXXX							
	NUT	5955																	
	DETAILING		0 X	XXXXXXXXXX															
	TOOLING		0 X					XXXXXXXXXX											
	MATERIAL PROCUREMENT		0 X					XXXX											
	EXTRUDING		0 X							XX									
	MACHINING		0 X							XXXXXXXX									
	ASSEMBLY		0 X									XXXXXXXXXX							
	ACTUATORS																		
	DETAILING		0 X	XXXXXXXXXX															
	MATERIAL PROCUREMENT		0 X					XXXX											
	MACHINING		0 X							XXXXXXXXXX									
	ASSEMBLY & TEST		0 X									XXXX							
	ASSEMBLY		0 X									XXXXXXXXXX							
	CONTROL VALVES																		
	MATERIAL PROCUREMENT		0 X					XXXXXX											
	MACHINING		0 X							XXXXXX									
	ASSEMBLY & TEST		0 X									XXXXXX							
	ASSEMBLY		0 X									XXXXXXXXXX							
	FRONT CRADLE MANIFOLD	5944																	
	DETAILING		0 X	XXXXXXXXXX															
	MATERIAL PROCUREMENT		0 X			XXXXXXXXXXXXXXXXXXXX													
	MACHINING		0 X							XXXXXXXXXX									
	ASSEMBLY		0 X									XXXXXXXXXX							
	MID CRADLE MANIFOLD	5943																	
	DETAILING		0 X	XXXXXXXXXX															
	MATERIAL PROCUREMENT		0 X			XXXXXXXXXXXXXXXXXXXX													
	MACHINING		0 X							XXXXXXXXXX									
	ASSEMBLY		0 X									XXXXXXXXXX							
	FITTINGS-ROSM																		
	MATERIAL PROCUREMENT		0 X			XXXXXXXXXXXXXXXXXXXX													
	ASSEMBLY		0 X									XXXXXXXXXX							
	SUBASSEMBLY	5710-600																	
	RAIL, UPPER	5841,97																	

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

FILE: LTHDLL

			1987											1988					
L	LONG LEAD ITEMS/SCHDL	Hr	Who	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	DETAILING	0	X	.....														
	TOOLING	0	X						.....									
	MATERIAL PROCUREMENT	0	X						.....									
	FABRICATING	0	X							.....								
	MACHINING	0	X								.....							
	ASSEMBLY	0	X									.....						
	TRAIL, LOWER FRONT	5843,99											...						
	DETAILING	0	X	.....														
	TOOLING	0	X						.....									
	MATERIAL PROCUREMENT	0	X						.....									
	FABRICATING	0	X							.....								
	MACHINING	0	X								.....							
	ASSEMBLY	0	X									.....						
	LATTICE	5933,34											...						
	DETAILING	0	X	.....														
	TOOLING	0	X						.....									
	MATERIAL PROCUREMENT	0	X						.....									
	FABRICATING	0	X							.....								
	MACHINING	0	X								.....							
	ASSEMBLY	0	X									.....						
	CANNON SUBASSY-NO MZ BRK	5710-250											...						
	RAILS	5963,64																	
	DETAILING	0	X	.....														
	ING	0	X						.....									
	MATERIAL PROCUREMENT	0	X						.....									
	EXTRUDING	0	X								...								
	MACHINING	0	X									.....						
	ASSEMBLY	0	X										.....					
	COLLARS	5781-111																	
	DETAILING	0	X	.....														
	TOOLING	0	X						.....									
	MATERIAL PROCUREMENT	0	X						.....									
	FORGING	0	X								...								
	MACHINING	0	X									.....						
	ASSEMBLY	0	X										.....					
	CANNON	5767																	
	MATERIAL PROCUREMENT	0	X	.....														
	ASSEMBLY	0	X										.....					
	CLAMP PLATE	5967																	
	DETAILING	0	X	.....														
	TOOLING	0	X						.....									
	MATERIAL PROCUREMENT	0	X						.....									
	EXTRUDING	0	X								...								
	MACHINING	0	X									.....						
	ASSEMBLY	0	X										.....					
	STR TEST TRAILS												.....					
	TEST TRAILS	0	X										.....					
	COMPOUND ACT ASSY/CRADLE	5710-260																	
	ASSEMBLY	0	X										...						
C	ASSY GIMB/PLATF	5710-340																	
	ASSEMBLY	0	X											...					



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FILE: LTHDLL



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FILE: LTHDLL

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

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FILE: LTHDLL

--ID--	STATUS	NAME	BUS DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	CAT
PHA 006		INCOMING/INPROCESS INSP										
PHA 008		SHIP TRAIL BULKHD/FITTING										
ACT 050		WHEEL BULKHEAD	5846									
TSK 040		DETAILING	25	3-12-87	4-15-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	10	7-08-87	7-21-87	UNASSIGNED		0				
TSK 160		FABRICATING & WELDING	25	7-29-87	9-01-87	UNASSIGNED		0				
TSK 200		MACHINING	3	9-08-87	9-10-87	UNASSIGNED		0				
TSK 210		SHIP	5	9-14-87	9-18-87	UNASSIGNED		0				
PHA 010		GIMBAL/PLAT/SPADE ASSY	5710-425									
ACT 010		GIMBAL	5811									
TSK 040		DETAILING	26	3-02-87	4-06-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	10	6-04-87	6-17-87	UNASSIGNED		0				
TSK 160		FABRICATING & WELDING	24	6-19-87	7-22-87	UNASSIGNED		0				
TSK 200		MACHINING	5	7-31-87	8-06-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	10	9-21-87	10-02-87	UNASSIGNED		0				
ACT 020		PLATFORM	5801									
TSK 040		DETAILING	16	3-02-87	3-23-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	12	4-02-87	4-17-87	UNASSIGNED		0				
TSK 160		FABRICATING & WELDING	40	4-24-87	6-18-87	UNASSIGNED		0				
TSK 200		MACHINING	4	6-24-87	6-29-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	10	9-21-87	10-02-87	UNASSIGNED		0				
ACT 030		SPADE	5821									
TSK 040		DETAILING	33	3-02-87	4-15-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	10	8-10-87	8-21-87	UNASSIGNED		0				
TSK 160		FABRICATING & WELDING	10	8-31-87	9-11-87	UNASSIGNED		0				

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

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---ID---	STATUS	NAME	BUS DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	GAT
TS 00		MACHINING	4	9-14-87	9-17-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	10	9-21-87	10-02-87	UNASSIGNED		0				
PHA 280		BOLTING										
TSK 040		MATERIAL PROCUREMENT	132	4-01-87	10-01-87	UNASSIGNED		0				
PHA 012		ASSY LD FTNGS TO CRADLE										
ACT 010		CRADLE	5831									
TSK 040		DETAILING	55	3-02-87	5-15-87	UNASSIGNED		0				
TSK 080		TOOLING	23	5-18-87	6-17-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	23	5-18-87	6-17-87	UNASSIGNED		0				
TSK 160		FABRICATING	38	6-23-87	8-13-87	UNASSIGNED		0				
TSK 200		MACHINING	17	8-24-87	9-15-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	10	9-21-87	10-02-87	UNASSIGNED		0				
ACT 010		FRONT CRADLE MANIFOLD	5944									
TSK 040		DETAILING	45	3-02-87	5-01-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	83	4-13-87	8-05-87	UNASSIGNED		0				
TSK 200		MACHINING	30	8-10-87	9-18-87	UNASSIGNED		0				
TSK 040		ASSEMBLY	10	9-21-87	10-02-87	UNASSIGNED		0				
PHA 014		STR TEST, RETEST GPSA										
TSK 010		PROCURE TEST SITE	33	3-02-87	4-15-87	UNASSIGNED		0				
TSK 040		TEST-RETEST	32	10-05-87	11-17-87	UNASSIGNED		0				
PHA 016		STR TEST, RETEST CRADLE										
TSK 040		TEST-RETEST	32	10-05-87	11-17-87	UNASSIGNED		0				
PHA 060		COMPOUND ACTUATOR ASSY	5710-275									
ACT 010		RECOIL CYLINDERS	5945,46,75									
TSK 040		DETAILING	40	3-02-87	4-24-87	UNASSIGNED		0				
TSK 040		TOOLING	40	6-08-87	7-31-87	UNASSIGNED		0				

MAR 02 87 ACTIVITY DETAIL
PROJECT: LTHD LONG LEAD ITEMS/SCHDL

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--ID--	STATUS	-----NAME-----	BUS DAYS	START	END	-----WHO-----	Hrs	AMOUNT CP LK PTY CAT
TSK 00	MATERIAL PROCUREMENT		20	6-09-87	7-06-87	UNASSIGNED		0
TSK 160	EXTRUDING		5	8-03-87	8-07-87	UNASSIGNED		0
TSK 200	MACHINING		30	8-17-87	9-25-87	UNASSIGNED		0
TSK 240	ASSEMBLY		32	10-05-87	11-17-87	UNASSIGNED		0
ACT 020	RECOIL RODS	5949,50						
TSK 040	DETAILING		40	3-02-87	4-24-87	UNASSIGNED		0
TSK 080	TOOLING		40	6-08-87	7-31-87	UNASSIGNED		0
TSK 120	MATERIAL PROCUREMENT		20	6-08-87	7-03-87	UNASSIGNED		0
TSK 160	EXTRUDING		5	8-03-87	8-07-87	UNASSIGNED		0
TSK 200	MACHINING		30	8-17-87	9-25-87	UNASSIGNED		0
TSK 240	ASSEMBLY		32	10-05-87	11-17-87	UNASSIGNED		0
ACT 030	END CAPS	5951,52						
TSK 040	DETAILING		40	3-02-87	4-24-87	UNASSIGNED		0
TSK 080	TOOLING		40	6-08-87	7-31-87	UNASSIGNED		0
TSK 120	MATERIAL PROCUREMENT		20	6-08-87	7-03-87	UNASSIGNED		0
TSK 160	EXTRUDING		5	8-03-87	8-07-87	UNASSIGNED		0
TSK 200	MACHINING		30	8-18-87	9-28-87	UNASSIGNED		0
TSK 240	ASSEMBLY		32	10-05-87	11-17-87	UNASSIGNED		0
ACT 040	NUT	5955						
TSK 040	DETAILING		40	3-02-87	4-24-87	UNASSIGNED		0
TSK 080	TOOLING		40	6-08-87	7-31-87	UNASSIGNED		0
TSK 120	MATERIAL PROCUREMENT		20	6-08-87	7-03-87	UNASSIGNED		0
TSK 160	EXTRUDING		5	8-03-87	8-07-87	UNASSIGNED		0
TSK 200	MACHINING		30	8-17-87	9-25-87	UNASSIGNED		0
TSK 240	ASSEMBLY		32	10-05-87	11-17-87	UNASSIGNED		0
r 050	ACTUATORS							

--ID--	STATUS	NAME	BUS DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	CAT
7. 40		DETAILING	46	3-02-87	5-04-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	13	6-09-87	6-25-87	UNASSIGNED		0				
TSK 200		MACHINING	45	7-06-87	9-04-87	UNASSIGNED		0				
TSK 160		ASSEMBLY & TEST	16	9-07-87	9-28-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	32	10-05-87	11-17-87	UNASSIGNED		0				
ACT 060		CONTROL VALVES										
TSK 120		MATERIAL PROCUREMENT	30	6-01-87	7-10-87	UNASSIGNED		0				
TSK 200		MACHINING	31	7-13-87	8-24-87	UNASSIGNED		0				
TSK 160		ASSEMBLY & TEST	24	8-25-87	9-25-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	32	10-05-87	11-17-87	UNASSIGNED		0				
ACT 070		FRONT CRADLE MANIFOLD 5944										
TSK 040		DETAILING	45	3-02-87	5-01-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	88	4-13-87	8-12-87	UNASSIGNED		0				
TSK 200		MACHINING	30	8-17-87	9-25-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	32	10-05-87	11-17-87	UNASSIGNED		0				
ACT 080		MID CRADLE MANIFOLD 5943										
TSK 040		DETAILING	45	3-02-87	5-01-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	88	4-13-87	8-12-87	UNASSIGNED		0				
TSK 200		MACHINING	30	8-17-87	9-25-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	32	10-05-87	11-17-87	UNASSIGNED		0				
ACT 090		FITTINGS-ROSAN										
TSK 120		MATERIAL PROCUREMENT	96	5-15-87	9-25-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	32	10-05-87	11-17-87	UNASSIGNED		0				
PHA 030		TRAIL SUBASSEMBLY 5710-600										
ACT 010		TRAIL, UPPER 5841,97										
TSK 040		DETAILING	45	3-02-87	5-01-87	UNASSIGNED		0				

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

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FILE: LTHDLL

--ID--	STATUS	NAME	BUS	DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	CAT
1-080		TOOLING		23	6-29-87	7-29-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT		23	6-29-87	7-29-87	UNASSIGNED		0				
TSK 160		FABRICATING		38	7-27-87	9-16-87	UNASSIGNED		0				
TSK 200		MACHINING		17	9-21-87	10-13-87	UNASSIGNED		0				
TSK 240		ASSEMBLY		8	10-22-87	11-02-87	UNASSIGNED		0				
ACT 030		TRAIL, LOWER FRONT	5843,99										
TSK 040		DETAILING		45	3-02-87	5-01-87	UNASSIGNED		0				
TSK 080		TOOLING		23	6-29-87	7-29-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT		23	6-29-87	7-29-87	UNASSIGNED		0				
TSK 160		FABRICATING		38	7-27-87	9-16-87	UNASSIGNED		0				
TSK 200		MACHINING		17	9-22-87	10-14-87	UNASSIGNED		0				
TSK 240		ASSEMBLY		8	10-22-87	11-02-87	UNASSIGNED		0				
ACT 040		LATTICE	5933,34										
TSK 040		DETAILING		45	3-02-87	5-01-87	UNASSIGNED		0				
TSK 080		TOOLING		23	6-29-87	7-29-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT		23	6-25-87	7-27-87	UNASSIGNED		0				
TSK 160		FABRICATING		38	7-27-87	9-16-87	UNASSIGNED		0				
TSK 200		MACHINING		17	9-21-87	10-13-87	UNASSIGNED		0				
TSK 240		ASSEMBLY		8	10-22-87	11-02-87	UNASSIGNED		0				
PHA 120		CANNON SUBASSY-MO MZ BRK	5710-250										
ACT 010		RAILS	5963,64										
TSK 040		DETAILING		35	3-02-87	4-17-87	UNASSIGNED		0				
TSK 080		TOOLING		40	7-13-87	9-04-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT		20	7-14-87	8-10-87	UNASSIGNED		0				
TSK 160		EXTRUDING		5	9-09-87	9-15-87	UNASSIGNED		0				
TSK 200		MACHINING		30	9-21-87	10-30-87	UNASSIGNED		0				

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

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ID	STATUS	NAME	BUS	DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	CAT
TSK 140		ASSEMBLY	24		11-03-87	12-04-87	UNASSIGNED		0				
ACT 020		COLLARS	5781-III										
TSK 040		DETAILING	33		3-02-87	4-15-87	UNASSIGNED		0				
TSK 080		TOOLING	40		7-13-87	9-04-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	20		7-14-87	8-10-87	UNASSIGNED		0				
TSK 160		FORGING	5		9-09-87	9-15-87	UNASSIGNED		0				
TSK 200		MACHINING	30		9-21-87	10-30-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	24		11-03-87	12-04-87	UNASSIGNED		0				
ACT 030		CANNON	5767										
TSK 120		MATERIAL PROCUREMENT	80		2-24-87	6-15-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	24		11-03-87	12-04-87	UNASSIGNED		0				
ACT 030		CLAMP PLATE	5967										
TSK 140		DETAILING	44		3-02-87	4-30-87	UNASSIGNED		0				
TSK 080		TOOLING	40		7-13-87	9-04-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	20		7-14-87	8-10-87	UNASSIGNED		0				
TSK 160		EXTRUDING	5		9-09-87	9-15-87	UNASSIGNED		0				
TSK 200		MACHINING	30		9-21-87	10-30-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	24		11-03-87	12-04-87	UNASSIGNED		0				
PHA 124		STR TEST TRAILS											
TSK 040		TEST TRAILS	38		11-03-87	12-24-87	UNASSIGNED		0				
PHA 070		COMPOUND ACT ASSY/CRADLE	5710-260										
TSK 240		ASSEMBLY	7		11-20-87	11-30-87	UNASSIGNED		0				
PHA 020		CRADLE ASSY GIMB/PLATF	5710-340										
TSK 040		ASSEMBLY	7		11-20-87	11-30-87	UNASSIGNED		0				
PHA 080		ALIGN WAYS TO GE/AZ AXIS	5710-175										
TSK 140		ASSEMBLY	7		12-01-87	12-09-87	UNASSIGNED		0				

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ACTIVITY DETAIL

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

FILE: LTHDLL

--ID--	STATUS	NAME	BUS	DAYS	START	END	WHO	Hrs	AMOUNT-CP	LK	PTY	CAT
Ph. J90		FIRE CONTROL (STATIC)	5710-400									
ACT 010		FIRE CONTROL LINKS	5848,49,50									
TSK 060		DETAILING		33	3-05-87	4-20-87	UNASSIGNED					0
TSK 105		TOOLING		23	8-10-87	9-09-87	UNASSIGNED					0
TSK 138		MATERIAL PROCUREMENT		23	8-10-87	9-09-87	UNASSIGNED					0
TSK 163		FABRICATING		38	9-14-87	11-04-87	UNASSIGNED					0
TSK 182		MACHINING		17	11-09-87	12-01-87	UNASSIGNED					0
TSK 240		ASSEMBLY		5	12-07-87	12-11-87	UNASSIGNED					0
PHA 150		INSTALL PSA MUZZLE BRAKE										
ACT 010		MUZZLE BRAKE	5766									
TSK 040		DETAILING		1	2-27-87	2-27-87	UNASSIGNED					0
TSK 080		PATTERN		35	4-27-87	6-12-87	UNASSIGNED					0
T 20		CASTING PROCESS		97	6-15-87	10-27-87	UNASSIGNED					0
TSK 200		MACHINING		25	11-02-87	12-04-87	UNASSIGNED					0
TSK 240		ASSEMBLY		14	12-07-87	12-24-87	UNASSIGNED					0
PHA 160		LOADTRAY AND WAY	5710-475									
TSK 240		ASSEMBLY		14	12-07-87	12-24-87	UNASSIGNED					0
PHA 170		FIRE CONTROL & OPT COMPL	5710-400									
TSK 060		SCOPE PROCUREMENT	5970	163	5-01-87	12-15-87	UNASSIGNED					0
TSK 240		ASSEMBLY		9	12-14-87	12-24-87	UNASSIGNED					0
PHA 130		CANNON SUBASSY TO CRADLE	5710-240									
TSK 240		ASSEMBLY		7	12-14-87	12-22-87	UNASSIGNED					0
PHA 100		HYDRAULIC PIPING NETWORK	5710-465									
ACT 010		ACTUATORS										
TSK 040		DETAILING		45	3-02-87	5-01-87	UNASSIGNED					0
T 20		MATERIAL PROCUREMENT		15	8-03-87	8-21-87	UNASSIGNED					0

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

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--ID--	STATUS	NAME	BUS	DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	CAT
100	200	MACHINING	55		8-25-87	11-09-87	UNASSIGNED		0				
TSK	160	ASSEMBLY & TEST	19		11-16-87	12-10-87	UNASSIGNED		0				
TSK	240	ASSEMBLY	9		12-14-87	12-24-87	UNASSIGNED		0				
ACT	020	CONTROL VALVES											
TSK	120	MATERIAL PROCUREMENT	44		6-09-87	8-07-87	UNASSIGNED		0				
TSK	200	MACHINING	57		8-17-87	11-03-87	UNASSIGNED		0				
TSK	160	ASSEMBLY & TEST	23		11-09-87	12-09-87	UNASSIGNED		0				
TSK	240	ASSEMBLY	9		12-14-87	12-24-87	UNASSIGNED		0				
ACT	030	FITTINGS											
TSK	120	MATERIAL PROCUREMENT	71		8-31-87	12-07-87	UNASSIGNED		0				
TSK	240	ASSEMBLY	9		12-14-87	12-24-87	UNASSIGNED		0				
PHA	030	TRAIL ASSY TO SYSTEM	5710-595										
TSK	240	ASSEMBLY	20		12-15-87	1-11-88	UNASSIGNED		0				
PHA	180	WALKING BEAM WHLS & AXLE	5710-625										
ACT	010	DISC BRAKE ROTOR	5748										
TSK	040	DETAILING	1		2-25-87	2-25-87	UNASSIGNED		0				
TSK	080	TOOLING	40		8-31-87	10-23-87	UNASSIGNED		0				
TSK	120	MATERIAL PROCUREMENT	20		8-31-87	9-25-87	UNASSIGNED		0				
TSK	160	EXTRUDING	5		10-27-87	11-02-87	UNASSIGNED		0				
TSK	200	MACHINING	30		11-10-87	12-21-87	UNASSIGNED		0				
TSK	240	ASSEMBLY	4		12-28-87	12-31-87	UNASSIGNED		0				
PHA	190	WALKING BEAMS	5710-650										
ACT	010	LEAD & LAGGING BEAMS	5732,3,92,3										
TSK	040	DETAILING	11		3-02-87	3-16-87	UNASSIGNED		0				
TSK	080	TOOLING	30		7-27-87	9-04-87	UNASSIGNED		0				
TSK	200	MATERIAL PROCUREMENT	50		7-27-87	10-02-87	UNASSIGNED		0				

ID	STATUS	NAME	BUS DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	CAT
TSK 200		FABRICATING & WELDING	45	10-12-87	12-11-87	UNASSIGNED		0				
TSK 200		MACHINING	10	12-14-87	12-25-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	4	1-05-88	1-08-88	UNASSIGNED		0				
ACT 020		CROSS SUPPORT	5803									
TSK 040		DETAILING	11	3-02-87	3-16-87	UNASSIGNED		0				
TSK 080		TOOLING	30	7-27-87	9-04-87	UNASSIGNED		0				
TSK 120		MATERIAL PROCUREMENT	50	7-27-87	10-02-87	UNASSIGNED		0				
TSK 160		FABRICATING & WELDING	5	11-19-87	11-25-87	UNASSIGNED		0				
TSK 200		MACHINING	5	12-09-87	12-15-87	UNASSIGNED		0				
TSK 240		ASSEMBLY	4	1-05-88	1-08-88	UNASSIGNED		0				
PHA 140		HYDR SYS STARTUP & CHKOUT	5710-470									
TSK 040		STARTUP/CHECKOUT	15	1-05-88	1-25-88	UNASSIGNED		0				
PHA 200		WALKING BEAMS TO TRAIL	5710-675									
TSK 240		ASSEMBLY	5	1-12-88	1-18-88	UNASSIGNED		0				
PHA 210		OPER INSIDE TEST/PROCD										
TSK 040		TESTING/PROCEDURES	37	1-12-88	3-02-88	UNASSIGNED		0				
PHA 214		HDR PIPING NTWK IN TRAILS										
TSK 040		PIPING IN TRAILS	7	1-15-88	1-25-88	UNASSIGNED		0				
PHA 216		BRAKE SYSTEM	5710-225									
TSK 240		ASSEMBLY	7	1-15-88	1-25-88	UNASSIGNED		0				
PHA 218		OPER OUTSIDE TEST/PROCD										
TSK 040		TESTING/PROCEDURES	32	1-19-88	3-02-88	UNASSIGNED		0				
PHA 220		TAIL LIGHT AND WIRING	5710-580									
TSK 240		ASSEMBLY	10	1-19-88	2-01-88	UNASSIGNED		0				
PHA 230		SPEED SHIFT ASSEMBLY	5710-575									
TSK 240		ASSEMBLY	10	1-19-88	2-01-88	UNASSIGNED		0				

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PROJECT: LTHD LONG LEAD ITEMS/SCHDL

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FILE: LTHDLL

—ID—	STATUS	NAME	BUS DAYS	START	END	WHO	Hrs	AMOUNT	CP	LK	PTY	CAT
1.	40	BASIC ISSUE ITEMS & CONTR 5710-200										
TSK 040		INSTALL	6	1-26-88	2-02-88	UNASSIGNED		0				
PHA 250		NAME PLATES & LOCATION 5710-500										
TSK 040		INSTALL	10	2-02-88	2-15-88	UNASSIGNED		0				
PHA 254		PREPARE TO SHIP										
TSK 040		PREPARE	15	2-16-88	3-07-88	UNASSIGNED		0				
PHA 270		SHIP TO ARMY TEST SITE										
TSK 040		SHIP	9	3-09-88	3-21-88	UNASSIGNED		0				
PHA 260		INSTL 1ST ART MUZZLE BRK										
TSK 240		ASSEMBLY	12	3-09-88	3-24-88	UNASSIGNED		0				
TOTAL PROJECT				2-24-87	3-24-88			0				

DESCRIPTION: KNOWLEDGE BASE AND LTHD FILE INDEX

STATUS:

The primary sources of information or references for the LTHD project and their respective status' are as follows:

Final Report. This document details the approach, methods, accomplishments and conclusions of the LTHD project. See the Table of Contents of Volume A for a concise description of the report. The report is current and complete.

LTHD Project Files. These documents, to be stored at FMC through the summer of 1989, are indexed by the knowledge base shown in this section (as marked up). In addition to the information indexed, the LTHD files also include:

1. LTHD Final Report Master
2. FMC PC files (on floppy disk)
3. FMC VAX and Cyber files (on tape)
4. FMC CAD files (on tape)
5. York CAD files (on tape)
6. 1/12 scale models of major components

AUTHORS: Bart Anderson, Scott Dacko

*list of units by price range
suppliers... PARKER
suppliers...*

LYTHD KNOWLEDGE BASEPage 2

ABEI
address...COLUMBUS, OH
employs...FUJI, SAM (CLOSED LOOP TRANSMISSIONS)
employs...MORRIS, AL (APPLICATIONS MANAGER)
employs...WOLFE, PAUL (VALVES)
phone...614-481-7414; 245-473 (TELEX)

ACP
address...ADVANCED COMPOSITE PRODUCTS; EAST HAVEN, CT
employs...CARUSO, RICK
phone...203-464-4647
info loc..FILE: LIGHTWEIGHT TONED HONITZER
supplies..FOAM

ACTUATORS
info loc...FILE: LIGHTWEIGHT TONED HONITZER
AIRCRAFT
info loc...FILE: LIGHTWEIGHT TONED HONITZER
narrower...MINNESOTA AIR NATIONAL GUARD
comments...USED TO MOVE HONITZERS

ALCOA
address...PITTSBURGH, PA
employs...DECKER, DICK (CENTRAL INQUIRY DIRECTOR)
phone... (800) 245-6333
supplies..HIGH STRENGTH-TO-WEIGHT MATERIALS
info loc..FILE: LIGHTWEIGHT TONED HONITZER

AM GENERAL
supplies..HUNTER PARTS
employs...Fanco, Rick; Proj Engr on MHW wheel, 313-523-8095
employs...Li, Tjong group supervisor on drive trains.

ANALBA CORP
address...P. O. Box 1409A, 10400 W. MITCHELL ST., WEST ALLIS, WI 53214
employs...JAMESON, JAMES
phone... (414) 453-9535
supplies..COMPOSITE CYLINDERS FOR HYDRAULIC ACTUATORS

AMCP-706-251
abstract...RECOIL SYSTEMS
per.....DOUB PAGE

AMCP-706-252
abstract...GUN TUBE DESIGN
per.....DOUB PAGE
see also..CANNONS

AMCP-706-342
info loc..FILE: LIGHTWEIGHT TONED HONITZER

AMERICAN HOLS
phone...571-8642

DIRECTORY

FILE: LIGHTWEIGHT TONED HONITZER

FILES REFERENCED
FILE: BART ANDERSON
FILE: DAVE PETERSON
FILE: HEND THEUNER
FILE: JACK DECKER
FILE: MIKE BRADON
FILE: SCOTT LAMBLE
NORTHERN/IN

*1. ADD NOTES FROM 10/15/85
ADDED*

DISTRIBUTION

LTHD KNOWLEDGE BASE.....Page 5

from.....TURF INN
 emp.....RIGHT ON WOLF; 87 NORTH TO 155; 155 EAST TO BALCONY
 (ABOUT 1 MILE)
 serving.....WATERVLIET

BALLISTICS RESEARCH LAB
 see.....BRL

BART
 info loc..FILE; LIGHTWEIGHT TONED MONITZER
 comments..WORKING NOTES

BATTLEING PROJECT
 reader....FORT STILL
 emp.....MAJOR BARFIELD, 14800, 13023
 info loc..FILE; LIGHTWEIGHT TONED MONITZER

BATTLE
 phone.....TELECOPY OFFICE, 614-424-7895
 phone.....TELECOPY, 614-424-3265

BCF
 emp.....LOBBING, NIMBY
 phone.....371-4218
 emp.....BRABET, KATHY
 info loc..FILE; LIGHTWEIGHT TONED MONITZER

BCF-A1
 abstract..RECORD OF ARTWORK PROVIDED FOR LTHD PROPOSAL BEFORE 850525

BCF-A2
 abstract..RECORD OF ARTWORK PROVIDED FOR LTHD PROPOSAL AFTER 850525

BEARINGS
 supplier...KAYSON
 supplier...FAG

BENET
 address...BENET WEAPONS LAB
 comment...THREE MAJOR DIVISIONS ARE RESEARCH, DEVELOPMENT AND
 ENGINEERING SUPPORT
 emp.....B. ANDREA, DR. GIULIANO (B); RESEARCH-CHIEF
 phone.....266-5704
 emp.....FISCELLA, RUBB
 phone.....518-266-6164 or 3801
 emp.....MALCOM, DALE; DEVELOPMENT-CHIEF OF ARTILLERY SUPPORT; CANNON
 CONFIRMATION

phone.....518-266-4162 or 3801
 emp.....MUMMEL, PAUL; DIRECTOR OF BENET (RETIRED)
 emp.....WILLIAMS, FRED; MODEL SHOP
 emp.....ZWEIG, DR. JOHN; 518-266-4241/5315
 see.....WATERVLIET (RESTAURANTS, MOTELS)

BEVERLY HERITAGE
 address...1870 BARBER LANE, MILPITAS, CA

LTHD Disk 11/FILE = DIR

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BLAST OVERPRESSURE
 measure - muzzle blast
 info at LTHD

LTHD KNOWLEDGE BASE.....Page 6

phone.....408-943-7080
 from.....SAN JOSE AIRPORT
 emp.....WHEN YOU EXIT AIRPORT, TURN RIGHT; FOLLOW WINDING ROAD; LEFT AT
 INTERSECTION, LEFT AGAIN AT NEXT INTERSECTION; NOW YOU'RE ONE
 17 NORTH; GO ABOUT FIVE MILES TO MONTAGUE, EXIT RIGHT THEN TAKE
 LEFT FORK (YOU'LL GO OVER 17 NORTH); HOTEL IS ON YOUR RIGHT (IN
 CORNER OF 17 AND MONTAGUE).

BOUCHER LEWIS

emp.....STEWART, BARY
 info loc..FILE; LIGHTWEIGHT TONED MONITZER
 phone.....927-7874
 supplier..MODELS

BRACKS

supplier...KELSEY-HAYES
 supplier...MIDLAND BRACK
 info loc..WAPPA BLK CRIC

BRECH
 info loc..FILE; LIGHTWEIGHT TONED MONITZER
 abstract..ARTICLES AND NOTES ON BRECHES
 see also..M109 SELF-PROPELLED MONITZER FILM

BRL

address...US ARMY BALLISTIC RESEARCH LABORATORY; ABERDEEN PROVING
 GROUND; MARYLAND; 21005
 emp.....SCHMIDT, ED; PND; LAUNCH AND FLIGHT DIVISION
 info loc..FILE; LIGHTWEIGHT TONED MONITZER
 info loc..FILE; SCOTT LANGLEIE
 see also..MUZZLE BRACKS
 used for..BALLISTICS RESEARCH LAB

BRUNSWICK

address...150 JOHNSTON ROAD; MARION, VA 24354
 emp.....DAVIS, RALPH; TECH DIRECTOR; 703-783-3121
 emp.....BUTRUM, RAY; PLANT MANAGER
 address...LINCOLN, NEBRASKA

emp.....MAHSHWARI, MANENDRA; PRODUCT MANAGER
 emp.....SPENCER, BRIAN; DESIGN
 emp.....MORRIS, BILL; PLANT MANAGER
 phone.....402-444-8211; extension 4300 for FACS
 address...437A BOULDER POINT DRIVE; MANCHESTER, NH 03022
 emp.....SMITH, MARGARET; MARKETING MANAGER; 314-726-9726
 info loc..FILE; LIGHTWEIGHT TONED MONITZER

CALSPAN

address...CALSPAN
 info loc..FILE; LIGHTWEIGHT TONED MONITZER
 see also..MUZZLE BRACKS
 see also..CANNONS

CANNONS

see also..MIL-S-46119 (FORGING), APEI (LIGHTWEIGHT), ANCP-706-252
 (DESIGN), COMPOSITE CANNON (800515), CALSPAN

LTHD Disk 11/FILE = DIR

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3

CEL address.....PNC CENTRAL ENGINEERING, 1105 COLEMAN AVE; BOX 580;
SANTA CLARA, CA 95052.
phone.....408-289-0111 (SWITCHBOARD FOR BOTH ORDNANCE AND CEL)
employees.....BILLET, RON; FOREMAN
employees.....BUNNELLE, PHIL
employees.....CHAKRABORTY, NARASIM; COMPUTERS
phone.....408-289-3606
employees.....CHAPARNE, BILL; FROM LEAR FAN
employees.....CHEN, CHIA-CHEN (GEORGE); STAFF ENGR, POLYMERS TECHNOLOGY
phone.....408-289-3877
employees.....GLADNEY, HAROLD; MODEL-MAKING SHOP; 408-289-2185
employees.....KRUGER, CURT; COMPOSITE LAB; USED TO LIVE IN MINNESOTA
employees.....NEWMAN, MITCH; 408-289-4787
employees.....ORLANDO, FRANK; HYDRAULICS; 408-289-3615
employees.....ORTLOFF, CHARLES (CHUCK); ANALYSIS OF COMPOSITES, STRUCTURES.
phone.....408-289-4437
employees.....PRATT, TOM; 408-289-3586
employees.....RYDER, ART; OVERALL TECH COORDINATOR FOR CEL
employees.....WANG, CC; 408-289-2226
employees.....WIEBERICH, JIM; MECHANICS LEADMAN; FOUR BAR LINKAGES.
from.....WYATT SAN JOSE
from.....SOUTH ON 17 TO COLEMAN; WEST ON COLEMAN TO 1105.
from.....OAKLAND AIRPORT
from.....SAN FRANCISCO AIRPORT
from.....SAN JOSE AIRPORT
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
notes.....BEVERLY HERITAGE
narrower...RECORD CONCEPTS
used for...PNC-CEL

CIBA-GEIGY
phone...714-964-2731
address... 10910 TAYLOR AVE.
FOUNTAIN VALLEY, CA
employees.....SMITH, LANCE

COMPOSITE ORDNANCE
broader...PROPELLANT
supplier...ARNTIC
COMPOSITE CANNON (800515)
author.....CRAIG D. DOUGLAS
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
publisher...ARMY MATERIALS AND MECHANICS RESEARCH CENTER, WATERTOWN, MA;
MAY 15, '80.
see also...CANNONS
title.....ADVANCED COMPOSITE APPLICATIONS TO LARGE CALIBER WEAPON
SYSTEMS.

COMPOSITES
broader...HIGH STRENGTH-TO-WEIGHT MATERIALS
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
narrower...STRUCTURAL SANDWICH COMPOSITES
abstract...COMPOSITE ARTICLES AND PROPERTY SUMMARIES

see also...ANMC
narrower...COMPOSITES FABRICATION
narrower...FOAM
COMPOSITES FABRICATION
broader...COMPOSITES
supplier...ARCO (METAL MATRIX)
supplier...HERCULES
supplier...LUNN
supplier...RECON
supplier...MATERIAL CONCEPTS (METAL MATRIX-CONTINUOUS
supplier...COMPOSITE SPECIALTIES (METAL MATRIX-WHISKER)
supplier...FIBER INNOVATIONS (BRAIDING)
supplier...DWA (SIC/A) CONTINUOUS
COMPOSITE FASTENERS
supplier...REINFOR/SPECIALTY FASTENER DIVISION
COMPOSITE FIBERS
supplier...CYANARID
COMPOSITE SPECIALTIES
address...CHATSORTH, CA
phone.....213-998-1304
supplies...COMPOSITES FABRICATION
COMPUTER PROGRAMS
broader...ANALYSIS
narrower...RECORD, SAS
CRABAR INDUSTRIES
address...COMPTON, CA
phone.....213-639-6211
CYANARID
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
supplies...COMPOSITE FIBERS
CYNO INDUSTRIES
supplies...FOAM (INDACELL)
employee...CARUSO, RICH
phone.....617-393-9622
phone.....203-795-6081
BAHLGREN
use.....NSMC
DESIGN REVIEW - SYSTEM
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
BICK
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
BIRECTORY
comments...THIS PRINT OUT
Info loc...FILE: LIGHTWEIGHT TONED MONITOR

LYTH Disk 11/FILE - DIR
Composite SPECIALTIES 21119 Supplier CA
DWA Marine LTHD CHATSORTH, CA
info at... 91311 JACKIE
supplies... Composite SPECIALTIES FAB ACTUAL
online... HAMMILL W C (AIA) JR PHD; 818-998-1504

add....NJ TURNPIKE (NTP) TO 200 (3 MI); 200 WEST TO 80 (16.3 MI); 80 WEST TO ROCKAWAY (8.7 MI); TURN LEFT TOWARD MIDBERRIA, AT STOP SIGN, AND GO ABOUT 0.5 MILE, ON RIGHT.
phone.....201-625-1200

HUMAN FACTOR
broaden...SHI

NUMBER
see also...TN 9-2320-280-10, ARMY TECH MANUAL
supplier...TACON

NUMBER PARTS
info loc..FILE; LIGHTWEIGHT TONED MONITZER
supplier...AN GENERAL
supplier...MOTOR WHEEL

NYATT SAN JOSE
from.....SAN JOSE AIRPORT
add.....SOUTH ON 101 FOR 34 MILES TO "FIRST STREET"

HYDRAULIC ACCUMULATORS
supplier...YORK
supplier...NBC
supplier...METAL BELLONS
supplier...YORK (locking option).

JOHN M. CUCKERMAN AND ASSOCIATES
address...DOVER, NJ
employ...McFARVEN, JEFF
phone.....201-378-7473
supplier...EN-PLASMA TECHNOLOGY

KAYDOM BEARING
address...MUSKOGEE, MI
phone.....616-755-3741
address...934 LINCOLN AVE, ST PAUL, MN, 55105
employ...RELAIR, CHUCK
phone.....642-5045
supplier...BEARINGS

KELSEY-WAYES
info loc..FILE; LIGHTWEIGHT TONED MONITZER
supplier...BRACKES
supplier...WHEELS
used for...WAYES INDUSTRIAL BRAKE

KENT
info loc..FILE; LIGHTWEIGHT TONED MONITZER
contents...WORKING NOTES AND SKETCHES

LUNN
info loc..FILE; LIGHTWEIGHT TONED MONITZER

LTMD Disk 11/FILE - DIR

1 GUARDIAN AIRPORT
718-476-1033
Page 13

P1 80 ENVS

LTMD ANALYSIS - BALLISTICS
abstract...PROGRAM DALLGREN, INPUT REQUIREMENTS, IMPORTANT RUNS
info loc..FILE; LIGHTWEIGHT TONED MONITZER

LTMD ANALYSIS - ELEVATION
abstract...PROGRAM ELV3, DAS FOR ANALYSIS OF RAISING & LOWERING MONITZER BARRELS
info loc..FILE; LIGHTWEIGHT TONED MONITZER

LTMD ANALYSIS - HOP
abstract...PROGRAM STABLES, DAS FOR ANALYSIS OF MONITZER "HOP" CONTAINS RUN OF LTMD HAS RECOIL STABILITY EVALUATION
info loc..FILE; LIGHTWEIGHT TONED MONITZER

LTMD ANALYSIS - RAW INPUT DATA
abstract...PROPOSAL SPECS, PRELIMINARY INPUT DATA
info loc..FILE; LIGHTWEIGHT TONED MONITZER

LTMD ANALYSIS - RECOIL ORIFICE
abstract...PROGRAM REC. FORT USED WITH RECOIL FORT TO CONFIGURE ORIFICES, ETC. OF A RECOIL MECHANISM
info loc..FILE; LIGHTWEIGHT TONED MONITZER
see also...ANALYSIS - RECOIL MANIPULATION, ARM ANALYSIS - GENERAL INFO

LTMD ANALYSIS - SLIDE
abstract...PROGRAMS SLIDE & SLIDE 2, HAS 2 DIFFERENT APPROACHES FOR MODELING SLIDE
info loc..FILE; LIGHTWEIGHT TONED MONITZER
see also...SEARCHES - SPADE

LTMD OPTIONS
info loc..FILE; LIGHTWEIGHT TONED MONITZER

LUNN
address...ENGINEERED COMPOSITES DIVISION; LUNN INDUSTRIES; NYARBARCH, NY, 11798.
employ...LOPEZ, JOE
info loc..FILE; LIGHTWEIGHT TONED MONITZER
phone.....516-643-8700
supplier...COMPOSITE FABRICATION

MAGAZINE ARTICLES

MARCONI
info loc..FILE; LIGHTWEIGHT TONED MONITZER
supplier...FIRE CONTROL

MARKETING INTELLIGENCE REPORTS
used.....HIR

MAROTTA SCIENTIFIC
address...BOONTON AV; BOONTON, NJ; 07005

LTMD Disk 11/FILE - DIR

KUPT
info loc..FILE; LIGHTWEIGHT TONED MONITZER
employ...62-572-4451

WAS SCOTLAND
720-1888
718-1888

8

EMPLOY...FILE, BILL, ACCT. ELEC. FOR NUMBER; 517-337-3720
 EMPLOY...FILES, BRUCE; 517-337-5839; HMMV WHEEL ENGR
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 supplies...NUMBER PARTS
 supplies...WHEELS

MTL
 see also...AMMC
 see also...AMMC

MTS
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 phone.....937-4000

MUZZLE BLAST (920611,1)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 info loc..FILE; SCOTT LAMBLIE
 publisher..AIAA-02-0056
 title.....THE RELATIONSHIP BETWEEN INTERIOR BALLISTICS, GUN EXHAUST
 PARAMETERS AND THE MUZZLE BLAST OVERPRESSURE.

MUZZLE BLAST (920611,2)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 info loc..FILE; SCOTT LAMBLIE
 publisher..AIAA-02-0973
 title.....TIME-DEPENDENT NEAR FIELD MUZZLE BLAKE FLOW SIMULATIONS

MUZZLE BRAKES
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 info loc..FILE; SCOTT LAMBLIE
 see also...BRL (CNS) SALISBURY, D'BRASKY REPORT; MIL-870-1474 (INT),
 noise limits; BRL (ED SCHMIDT), national report.

MUZZLE BRAKES (7610)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 publisher..NSWC/ML TR-3531
 title.....MUZZLE BRAKE PARAMETER STUDY

M109 SELF-PROPELLED MONITOR FILM
 info loc..MORTHEM/AV
 see also...BREECH

M114 MANUAL
 see also...TR 9-1025-200-12

M109 SPECIFICATIONS
 see also...MIL-N-45906 (AR), PROCUREMENT.

M109 CARRIAGE (7207)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 title.....MONOLITHIC NI STRENGTH ALUMINUM BOTTOM CARRIAGE STRUCTURE
 FOR ... IN198.

M109 CARRIAGE (7211)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR

LTMD Dist 11/11/10 - 818

MUZZLE BLAST OVERPRESSURE
factor

11110.....INITIAL TESTING OF A HIGH STRENGTH CAST ALUMINUM BOTTOM
 CARRIAGE FOR THE 155 MM, IN198.

M109 FIRING TABLE (7210)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 abstract...MATHEMATICAL FIRINGS OF IN198

M109 MANUALS
 see also...TR 9-1025-211-206P

M109 RECOIL
 broader...RECOIL
 see also...MIL-N-45906 (AR)
 see also...PROCUREMENT

M109 RECOIL (7109)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 title.....DESIGN DATA ON THE IN45 RECOIL MECHANISM

M109 RECOIL (7201)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 title.....RECOIL PRESSURE TEST, IN45 RECOIL MECHANISM,
 IN198 TONED 155 MM, MONITOR.

M109 RECOIL (7212)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 title.....DESIGN OF CONTROL GROOVES FOR 155 MM MONITOR, IN198.

M109 TESTING (7203)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 title.....INITIAL ROAD TESTING OF THE ... IN198 ADVANCED DEVELOPMENT
 MODEL.

M109 TESTING (7206)
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 title.....CAMP RECOY FIRING TESTS OF THE ... IN198 ADVANCED DEVELOPMENT
 MODEL.

M109 WEIGHTS
 info loc..FILE; LIGHTWEIGHT TONED MONITOR
 related...SIMPSON (850306)

NAVAL SURFACE WEAPONS CENTER
 see also...NSWC

NAVPRO

NEWARK AIRPORT
 phone.....201-724-4021 (PAGING)

NORICUM

CONCEPT...PRODUCTIONIZED SRC BC-45 INTO BMM-45
 info loc..FILE; LIGHTWEIGHT TONED MONITOR

NOB

LTMD Dist 11/11/10 - 818

L1M05
AIRGOUND 201-575-4539
ALISTO CAP 201-887-2726
KIMBUES 201-334-1844

7:30 PM
Home
37th Avenue

ALIGNMENT DAN KARTUM (was in 1981)
TRIDENT - GARY OACNS
MF45 - GREG KRIER
OPTICS - GREG KRIER

NITROGEN BOOSTERS
info loc... LTMD

ARDEC to Newark Airport :

At Dover :

Take interstate 80 east for 12 miles. Take exit 47 to interstate 280. Take 280 for 19 miles then take NJ Turnpike - Harrisburg exit. Then keep right. Pay toll. Take NJT south exit. Go 2 mile take interstate 78 exit. Take state highway 24 exit. Take state highway 1 and 9 exit. Take exit for rental cars at airport. Record gas and mileage on rental car.

see also...SALISBURY, notes (see discussions with each salisbury)
see also...PROPELLANT

PICATINNY (841004)
abstract...PRELIMINARY LITH SLIDE SHOW

PLNS
info loc...FILE: LIGHTWEIGHT TOWED MONITOR
used for...POSITION LOCATION REPORTING SYSTEM

POSITION LOCATION REPORTING SYSTEM
used...PLNS

POWERED METAL PARTS
supplier...VALDORN (HIGH STRENGTH)

PRESENTATIONS
see also...ORGANIZATION PRESENTED TO (ONE WAY RELATIONSHIP)

PROJECT APPROVAL REQUEST PAPERWORK
used...PAR

PROPELLANT
narrower...COMBUSTIBLE ORDNANCE
see also...PICATINNY (ECAT DEBLEY)
see also...RSCC (JIN O DRASBY)

ROAD CITY AIRPORT
from...RFA (BLDG 102 VIA EAST GATE)
exp...EAST ON ROADWAY, DO NOT TAKE AN EXIT BEFORE EXITING ARSENAL; L
ST 14TH ST AND 4TH AV (ONE-WAY); STAY ON 4TH; TURN R AT 19TH
ST; STAY ON 19TH ST; TAKE Y TO RIGHT; CROSS ROCK RIVER
(HAROLD'S ON RIGHT); FOLLOW SIGNS TO TERMINAL.
serving...RFA

RECOIL
narrower...M198 RECOIL

RECOIL (7296)
info loc...FILE: LIGHTWEIGHT TOWED MONITOR
title...MODELLING EFFECTIVE FLUID COMPRESSIBILITY IN A PUTEAUX RECOIL
MECHANISM.

RECOIL ANALYSIS
info loc...FILE: LIGHTWEIGHT TOWED MONITOR
abstract...RECOIL CALCULATIONS AND CRT PRINT-OUTS

RECOIL CONCEPTS
broader...CEL
info loc...FILE: LIGHTWEIGHT TOWED MONITOR

PROPAINTORY AGREEMENTS

RECON
address...8291 PENN AV, IRWIN, PA
phone...412-795-7222
supplies...COMPOSITE FABRICATION

REINFOR/SPECIALTY FASTENER DIVISION
supplier...COMPOSITES FASTENERS
address...CHICAGO, IL
employs...Bunnell, Ed
phone...312-941-4055
address...Tarrant, CA
phone...213-534-5744

REYNOLDS
address...REYNOLDS METALS
phone...804-281-2000
supplier...HIGH STRENGTH-TO-WEIGHT MATERIAL
info loc...FILE: LIGHTWEIGHT TOWED MONITOR

RFA
airport...ROAD CITY AIRPORT
employs...Cooper, Barry Tech Director-Corruption Officer; ANMC-PBC.
phone...309-782-6474
employs...Britton, Bob Logistics; reports to Bob Coz; worked on high OE
loading.

info per...Bob Scholde
employs...Kialer, Bill; RFA Planning; SHCRI-APR; 309-782-3636.
employs...McBee, Robert; ANCCOR HQ Corruption Officer; ANMC-PBC.
phone...309-782-6777.
employs...Pease, R. G.; Artillery Production Management; ANMC-PBA.
phone...309-782-3264.

food...HAROLD'S
from...HAROLD'S
exp...ITD ENTER AT WEST GATE; GO TO MAIN ROAD (32ND); TURN L AND GO
TO STOP; TURN R; STAY ON 14TH ST TO 23RD; L AT 23RD AVE TO 12TH
ST; R DOWN 12TH ST TO 19TH AV; L ON 19TH AV (TURNING INTO 10TH
AV) TO 30TH ST; TURN RT AND GO DOWN 30TH ST THRU 7TH; FOLLOW
BEND TO LEFT (DESIDE TRACK); TURN INTO 3TH AV; THEN TURN INTO
4TH; R ON 24TH ST; UP RAMP AND TURN R TO ROCK ISLAND ARSENAL.
TELL GUARD WHO YOU WANT TO VISIT AND HIS/HER BLDG NUMBER; MUST
GO TO BLDG 102 TO SIGN -IN; (TO BLDG 102) GO DOWN ROAD, BEAR TO
RIGHT (RODMAN AV) TO BILLESPIE; TURN RT; BLDG 102 ON IMMEDIATE
L; GO TO SECOND FLOOR.
info loc...FILE: LIGHTWEIGHT TOWED MONITOR
phone...TELE-COPIER; 309-782-4803
used for...ROCK ISLAND ARSENAL

used...RFA
info loc...FILE: LIGHTWEIGHT TOWED MONITOR
phone...309-782-6001
used for...ROCK ISLAND ARSENAL
info loc...FILE: LIGHTWEIGHT TOWED MONITOR
phone...309-782-6001
used for...ROCK ISLAND ARSENAL
info loc...FILE: LIGHTWEIGHT TOWED MONITOR
phone...309-782-6001
used for...ROCK ISLAND ARSENAL

Address...COMMANDING GENERAL ANCCOR
ATTN: ANMC-LSO-B
Rock Island, IL; 612-99-6000
Buttsworth, Don; ILS per the LTMD
DuPont Engineering Co. Inc. - Kent

GEORGE BUPPICK
M198 RECOIL
REC'D 6/1/80

phone.....815-964-3463
supplies...YORK

561

address...SCIENCE APPLICATIONS INTERNATIONAL CORPORATION, 1710
GOODRIDGE DRIVE, McLEAN, VIRGINIA.
employs...SEYMOUR KRAVITZ; MANAGER, WASHINGTON OFFICE; TRAINING
SYSTEMS AND ANALYSIS DIVISION
phone.....703-736-5974
address...SCIENCE APPLICATIONS; 2615 PACIFIC COAST HIGHWAY, SUITE 500;
HERNOSA BEACH, CA; 90254
employs...IRVING B. OSOFSKY; CHIEF ENGINEER; APPLIED TECHNOLOGY
OPERATION
phone.....213-318-2611

Info loc...FILE: LIGHTWEIGHT TONED MONITOR

SALSBURY

Info loc...FILE: LIGHTWEIGHT TONED MONITOR
abstract...NOTES FROM TALKING WITH MARK SALSBURY
see also...MUZZLE BRAKES; SOFT RECOIL; PICATINNY.

SAN FRANCISCO AIRPORT

comment...For Avia Express; go to center island on top level and tell driver
your name.

SAN JOSE AIRPORT

free.....CEL

exp.....R on Coleman, L at Airport Blvd, follow signs.

SCHMIDT

Info loc...FILE: LIGHTWEIGHT TONED MONITOR
comments...NOTES FROM BOB SCHMIDT

SCOTT

Info loc...FILE: LIGHTWEIGHT TONED MONITOR

SEALS (MILITARY)
supplier...SHANDAN

SEARCHES - SPADE

abstract...OTIC SEARCHER FOR INFO ON MONITOR SPADES
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
see also...LTH ANALYSIS - SLIDE

SHANDAN

address...PORT MAYNE, IN
address...LUCAS, OHIO
phone.....219-743-3723

address...SHANDAN RECOGNANCE; 1855 CENTINELA AVE.; SANTA MONICA, CA; 90404

employs...HAGER, BOB; 213-
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
supplies...SEALS (MILITARY)

SIMPSON

comment...WORKED ON ROMING'S LUTH PROJECT. EMPLOYED BY 8501.

LTHD Disk 111/1110 - DIR

Info loc...FILE: LIGHTWEIGHT TONED MONITOR
address...SUITE 111; 6433 TOPANGA CANYON BLVD; CANOGA PARK, CA; 91303.
phone.....818-884-9714

SIMPSON (850304)

related...M190 WEIGHTS

SMI

address...MURAN FACTORY
used for...SOLDIER-MACHINE INTERFACE

SOFT RECOIL

see also...SALSBURY

SOLDIER-MACHINE INTERFACE

use.....SMI

SRC

address...SPACE RESEARCH CORPORATION
Info loc...FILE: LIGHTWEIGHT TONED MONITOR
see also...PHOENIX

STANDARD

Info loc...FILE: LIGHTWEIGHT TONED MONITOR
employs...MANKEY, MARK; 214-337-8911
employs...PETRASEK, ELMER; KNOWS JACK BECKER

STEEL-UHS

Info loc...FILE: LIGHTWEIGHT TONED MONITOR
abstract...NOTES ON ULTRA-HIGH STRENGTH STEEL PROPERTIES INCLUDES WIRE
ROPE

STRUCTURAL SANDWICH COMPOSITES

broader...COMPOSITES
see also...NLC-HDBK-23A

TACON

address...WARREN, MICHIGAN

phone.....313-374-5000; GENERAL

phone.....313-374-7151; NUM-V SYSTEM MGR; KEITH BARTHLON
supplies...MUNNER

TANK

abstract...TANKS FOR HYDRAULICS
Info loc...FILE: LIGHTWEIGHT TONED MONITOR

TITANIUM

broader...HIGH STRENGTH-TO-WEIGHT MATERIALS
Info loc...FILE: LIGHTWEIGHT TONED MONITOR

TITECH

employs...Edwards, Nilo
phone.....714-395-7053

address...4000 WEST VALLEY BLVD; POMONA, CA; 91769
employs...NEWMAN, JEREMY; SENIOR VP of MGTNG;

LTHD Disk 111/1110 - DIR

YORK

FROM —

SHERATON - WEST MANCHESTER

EAST ON 30, UNDER 83; MAKE NEXT LEFT (TORONTO)

SHERATON - WEST MANCHESTER

FROM —

DULLES

GET TO BELTWAY AROUND WASHINGTON (495)

95 N TO 695 (BELTWAY AROUND BALTIMORE)

695 TO 83 N TO YORK

EXIT ON RT 30. (9W) ↓

(GO WEST (EXIT RIGHT & DO 270°))

WEST ON RT 30 ~ 3 MILES

EXIT ON RT 74 NORTH; YOU'LL SEE MOTEL ON RT
(NW CORNER).

FACE EXIT 9E (RT 30)

From.....HARRISBURG AIRPORT
 map.....Down 831 down center to intersection of BL 30 (west) go to first
 light and turn left (Toward) down Toward to 1730.
 supplies... ACTUATORS-ULTRA LIGHT
 send by... SIMULTANEOUS-WEST MANCHESTER

From Newark — NJT south to EXIT 6; (Pennsylvania TP); Follow signs to
 Harrisburg on PTP; on EXIT 21g
 EXIT 17 (LANCASTER/READING); PUTS
 ON 222 SOUTH; GO TO ~~RT~~ 30 WEST;
~~BEWARE~~ - TO STAY ON 30 YOU MUST
 BEAR RIGHT;
 L AT Howard Johnson at Toward

- NOTES: INFORMATION ORGANIZATION AND EXPLANATION OF SYMBOLS
1. INFORMATION WITHIN THE DIRECTORY IS ORGANIZED IN ABBREVIATED SENTENCE FORMAT
- SUBJECT
 verb.....OBJECT
- 1.A. THERE ARE NO CONSTRAINTS ON SUBJECT LENGTHS OR CHARACTERS, EXCEPT THAT THE SLASH (/) BE USED ONLY AS SHOWN BELOW.
- 1.B. HIERARCHICAL SUBJECTS ARE HANDLED IN THE FOLLOWING MANNER:
- SUBJECT/
 LEVEL 2 OF SUBJECT/
 verb.....OBJECT FOR SUBJECT LEVEL 2
 LEVEL 3 OF SUBJECT
 verb.....OBJECT FOR SUBJECT LEVEL 3
 verb.....OBJECT FOR SUBJECT LEVEL 1
- 1.C. MULTIPLE LINES OF SUBJECT ARE HANDLED IN THE FOLLOWING MANNER:
- SUBJECT LINE 1
 SUBJECT LINE 2
 SUBJECT LINE 3
 verb.....OBJECT
- 1.D. VERBS ARE PRE-ASSIGNED (BEFORE USE) AND EITHER ONE-WAY OR TWO-WAY (RECTIPROCAL). SEE NOTE 1.J. FOR A LISTING OF THE VERBS IN USE IN THIS DIRECTORY.
- 1.E. HIERARCHICAL VERBS ARE HANDLED IN THE FOLLOWING MANNER:
- SUBJECT
 verb.....OBJECT FOR VERB LEVEL 1
 verb.....OBJECT FOR VERB LEVEL 2
 verb.....OBJECT FOR VERB LEVEL 2
- 1.F. THERE ARE NO CONSTRAINTS ON OBJECT LENGTHS OR CHARACTERS.
- 1.G. MULTIPLE LINES OF OBJECT ARE HANDLED IN THE FOLLOWING MANNER:
- SUBJECT
 verb.....OBJECT LINE 1
 OBJECT LINE 2
 OBJECT LINE 3
- 1.H. THE SORTING SEQUENCE (ASCII) IS AS FOLLOWS (FIRST CHARACTER IS A SPACE):
- 0123456789:;<=>?@
 ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_`
 abcdefghijklmnopqrstuvwxyz{|}~

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1
2-----MACRO FILE NAME
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n location...
partner.

D.J. LEGAL VERBS

verb	reciprocal	reciprocal is
abstract...		
address...		
author...		
broaden...	narrower...	mandatory
color code		
comment...		
abstract...		
distance...		
dress code		
employs...		
food.....	serving...	mandatory
equiv.....	equiv.....	mandatory
free.....		
has info...	info loc...	optional
has info loc...	has info loc...	mandatory
keep.....	serving...	mandatory
meal.....	broaden...	mandatory
narrower...		
owner.....		
user.....		
phone.....		
procedure...		
publisher...		
rec. by...	recommends	mandatory
recommends	rec. by...	mandatory
related...	related...	mandatory
see also...	see also...	mandatory
see also...	food.....	mandatory
serving...	note.....	mandatory
supplier...	supplier...	mandatory
supplies...	supplier...	mandatory
title.....		
to.....		
use for...	used for...	mandatory
use for...	use...	mandatory

2. FILES UNDER DIRECTORY CONTROL (LISTED AT FIRST PAGE OF DIRECTORY)

2. A. SHOULD HAVE A LABEL ON THE LEFT HAND SIDE OF THE FIRST FILE OF EACH DRAWER
THAT IDENTIFIES THE FILE GROUP (E.G. LIGHTWEIGHT TONED MONITIZER).

2.2.9. SHOULD HAVE A LABEL ON THE RIGHT SIDE OF EACH FOLDER THAT IDENTIFIES THE STARTING LABEL OF CONTENTS OF THAT FOLDER (EG. GENET).

2.C. SHOULD HAVE THE CONTENTS OF EACH "PARCEL" OF INFORMATION LABELED AND DATED/SUCH THAT EACH PARCEL, IF BORROWED, CAN BE RETURNED TO ITS EXACT AND IF REFERENCED, CAN BE SPECIFICALLY REFERENCED. A FEW EXAMPLES OF LABELS THAT PROVIDE SUITABLE LOCATING CODES FOLLOW:

REELS THAT PROVIDE SUITABLE LOCATING COILS FOLLOW:

BENET (050301)	INFORMATION ACQUIRED 1 MAR 1985
BENET (050301A)	INFORMATION ACQUIRED 1 MAR 1985, SHEET A
BENET (050301 P61)	INFORMATION ACQUIRED 1 MAR 1985, PAGE 1

S. DAKO - 6/25/86

FILES ADDED

RECOMMECHANISMS - ACTIVE
RECOIL MECHANISMS - DESIGN
FOUNDATIONS - WEAPONS
SOIL STABILIZATION
HELICOPTERS - STRUCTURAL RESONANCE
SOIL MODELING + LOADING
UNICHAIR
LASEING

GRADE DESIGN
PROTECTIVE DEFORMATION
MIRB DESIGN CALCULATIONS

PROTECTIVE + CHARGE INFO
~~DESIGN~~ DESIGN SPECS - LTHD
STATEMENT OF WORK - LTHD
AMCP 706-395

AMCP 706-340

E.C. 887

E.C. 984

E.C. 1039

E.C. 641

TM 9-2350-253-20P-2

TM 9-2350-217-10N

5/1/86
S. DAKO

FILES ADDED TO PROJECT FILE

FILE NAME

CORTLAND CABLE CO.
WATERWAYS EXPERIMENT STATION / SW Research Institute
"HUMP" TESTS (RAIL CAR TEST)
TOWING STABILITY
MARCOTTA
RUSSELL ASSOCIATES
APG (ABERDEEN PROVING GROUNDS)
NOD (MCRAS)
KATON
EMERSON
VALVES
PACIFIC
COMPOSITE JOINTS
ARMY GAZETTE
FIELD ACTIVITY JOURNAL
CAPTAINS
MIRB MUZZLO BRACK
NOD-350-0015 (PHASE 1 DOCUMENTS)
MIR'S IN PROCESS
DESIGN REVIEW (860604)
PROPRIETARY AGREEMENTS
C.C. WANG
DYNAMIC ANALYSIS REPORT
FEDERAL EXPRESS FORMS
MAPS
B-13200, FJ

S. DAKO - 7/17/86

ADDED TO FILES:

APG - MT-4503

MIL-HDBK-23A

JANES

DARCOM - P-706-253

AMCP 706-344

MIL-HDBK-700

AMCP 706-250

AMCP 706-343

AMCP 706-286

AMCP 706-341

AMCP 706-190

FC 6-20-1

~~AMCP 706-347~~

~~AMCP 706-347~~

AMCP 706-347

ARM ANALYSIS - COMPUTER RUNS

DTIC LISTS

50 KM ~~ARM~~ ANALYSIS - COMPUTER RUNS (FIFTY)

AMCP 706-342

MURZLE BRAKE ANALYSIS

TM 43-0001-28-2

FMC - ARDEC Phase 2 "kick-off"

7/30/86

Name	Organization	TEL. NO.
Ray ESPINOSA	SMCAR-FSA-F	(201) 724-4307
Joseph M. ARGENTU	AMSMC-QAF-T	(201) 724-4238
JOHN G. SMISEL	ANSLC-QAR-G	201-724-4766
RALPH BECKER	SMCAR-FSA-F	(201) 724-5427
SANDY CHISHOLM	ANSMC-PCW-A	201-724-3217
Kevin MINER	SMCAR-CCB-RT	518-266-5682
K.R. GANDHI	AMTL	8-955-5404
F.E. St. Stanislawski	SMCAR-ALT-O	201 724 5859
SCOTT G. DACKS	FMC/NOD	612-572-6038
Garry Roosma	FMC	201-328-0650
Robert Rothe	FMC	612-572-6069
Lauren Rezac	FMC	612-572-6398
Bruce Zierwick	FMC	612-572-6394
Steve French	FMC	612-572-6056
JEFF IRELAND	FMC	612-572-7629
BART ANDERSON	FMC	612-572-6070
Herb Theumer	FMC	612-572-6060
David Peterson	FMC	612-572-6333
Norman T. Lionetti	SMCAR-FSA-F	201-724-5427
Harold Liberman	SMCAR-FSA-F	201-724-4117
Stephen G. Floroff	SMCAR-FSA-F	201-724-4171

FMC Kick off Meeting Attendance List

Hubb Thumier FMC Northern (612) 572-6660
D.W. Oplinger MTL (SECHT-MS) 617 923 5166
Waterman MA 02192 923

BART ANDERSON FMC NORTHERN 612-572-6070
SCOTT DACKO FMC NORTHERN 612-572-6038
SANDOR EINSTEIN AED Population Br. (201) 724-2447
Harold Liberman AROC (over) 201 724 4117
David Peterson FMC Northern 612-572-6233
Jack Becker FMC Northern 612-572-6586
Norm Liowett AROC SMCAR-FSA-F 201-724-3693
Joseph M. Acogito AMCOM AMSMC-QAH-T 201-724-4438
MACK A STRANER AMCOM AMSMC-QAH-T 201-724-4238
Charles J. Friedrich AMCOM AMSMC-QAH-T 201-724-5528
Gino R. De Togni AMROC-HUNTER LAS DET. 201-724-3217
Alfred S. Stodolinski PLASTEC SMCARACT-O 201 724 5109
AROC 201 724 6059

Rick Island Arsenal Gen I.A. 309-782-6001
Bill Kimble 782-3636 - 782-3777
Bess: Ron Sikorsky 309-784-5912

BART GEN PATTERN 780-3518

Please Print

Name	Organization/Title	Phone #
David Peterson	FSAIC / Sgm Mgr	(612) 572-6333
Bart Anderson	FMC Proj Eng	612 572-6070
Hubb Thumier	FMC Project Mgr.	(612) 572-6660
Charles J. Friedrich	FSAIC / Assoc. R. Sys. Design	(612) 572-6333
Jim Williams	PM-CAWS	201-724-2003
RANDY ESPINOSA	SMCAR-FSP-F	(201) 724-4307
KARL GANDHI	MTL AED MSEL	617-923-5404
J.N. LESKO, JR	MTL AED MSEL	5746/5746
Harold Liberman	SMCAR-FSA-F Proj. Officer	201-724-4117
Norm Liowett	SMCAR-FSA-F Mch. Eng	201-724-3693
Stephen G. Floroff	SMCAR-FSA-F Mech. Eng	201-724-4171
Mark K. Dale	SMCAR-CCB-DM (Comms)	(518) 226-5801
Stephen G. Johnson	ATTF-TM-CN (FS Inc. Hk)	(405) 351-1902
SANDOR EINSTEIN	SMCAR-AEE-BP	(201) 724-2447
THOMAS HARTIGAN	AMSIC-QAR-Q (Tech. Assur)	(201) 724-2352
CHARLES MAURER	SMCAR-FSE-D	(201) 724-7991
William H. Struck	SMCAR-FSE-BZ (Contract)	(201) 724-6940
AL FILORETO	" "	" - 6041
D.S. Ruthenworth	AMSIC-LSO-B (R)	417-393-3927
KENNEDY BATEMAN	YORK AERO	717-876-1988
ALPH BECKER	SMCAR-FSA-F	(201) 724-5427
David Hixson	SMCAR-FSA-F	(201) 724-2202
Gino R. De Togni	SLCHE-AR (HUNTER)	(201) 724-3217
Ken Yagrich	AMSIC-QAR-Q	(201) 724-5906
John G. Swisak	AMSIC-QAR-Q	201-724-4766
Tia Stackland	FMC Product Mgr (Cannon Systems)	612-572-6332
RAY MESEINA	AMSIC-QAR-I (Mech. Eng)	(201) 724-5877
OWALD A SWERTZER	POAK MECHANICAL	(717) 616-1900
Jim Hixson	SMCAR-FSA-F (over)	(201) 724-2352

FMC - ARDEC Phase 2 "kick-off"

7/30/86

Name	Organization	TEL. NO.
Ray ESPINOSA	SMCAR-FSA-F	(201) 724-4307
Joseph M. ARGENTU	AMSMC-QAF-T	(201) 724-4238
JOHN G. SMISEL	AMSMC-QAF-Q	201-724-4766
RALPH BECKER	SMCAR-FSA-F	(201) 724-5427
SANDY CHISHOLM	AMSMC-PCW-A	201-724-3217
Kevin Miner	SMCAR-CCB-RT	518-266-5682
K.R. GANDHI	AMTL	8-955-5404
F.E. St. Slobazinski	SMCAR-ALT-O	201 724 5859
SCOTT G. DACKS	FMC/NOD	612-572-6038
Garry Roosma	FMC	201-328-0650
Robert Rothe	FMC	612-572-6069
Lauren Rezac	FMC	612-572-6398
Bruce Zierwick	FMC	612-572-6394
Steve French	FMC	612-572-6056
JEFF IRELAND	FMC	612-572-7629
BART ANDERSON	FMC	612-572-6070
Herb Theumer	FMC	612-572-6060
David Peterson	FMC	612-572-6333
Norman T. Lionetti	SMCAR-FSA-F	201-724-5427
Harold Liberman	SMCAR-FSA-F	201-724-4117
Stephen G. Floroff	SMCAR-FSA-F	201-724-4171

FILES ADDED - ~~SECRET~~

BLAST OVERPRESSURE	860811
PHOENIX CONTROLS	"
ARLCD - TR - 85007	"
ACTUATORS - ULTRALIGHT	"
PATENTS	"
TM - 9 - 1240 - 375 - 34	860815
DWA COMPOSITES	860822
FORM - A3 COPIES	860825
TITECH	860909
REPLIES TO EVAL COMMENTS - 860909	860909
N/STERS	
FMC - OK	861005
BLACKHAWK	861019
YIL - H - 60830	"
E.C.C. 1165	8909-
M198 BRAKES	861116
DRAWING PACKAGE	861126
HOURS WORKED - LHD CREW	861126
COST TRACKING	"
SAHARS	861126
QUOTES	8612-2
ENGINE	861217
OPF MET	861219
FAFNIR	861229

ALIGNMENT EQUIPMENT	861229
THREAD INSERTS	861229
SYSTEM OPERABILITY	861231
STABILITY ANALYSIS	"
WEIGHT HISTORY	"
PRIMER AUTOLOADERS	"
CANNON ASSY ANALYSIS	"
LOAD CONDITIONS -	"
FEDERAL EXPRESS	870108
FIRE CONTROL ANALYSIS	870119
SHIPPING FORMS	870121
SHIPPING RECORDS	"
ACMC (FORMERLY ARCO)	870201
FIBERTECH	870201
SHIPPING - TRANSPORTABILITY REQ'TS	870208
MIL - STD - 810D	"
130	"
889	"
HEXCEL	870211
MIL-C-83488	"
CADILLAC PLASTIC	870305
CIBA GEIGY	"
HEATH TECNA	"
HITCO	"
MORTON-THICKOL	"
TERMINAL	"
JET EDGE CORP.	"
CABLES	"
TM 9-2350 - 704-20	870308
CANNON ASSY DWGS	870311
SYS. ENG. DOCS.	870314

TEST _____ 870324
GALVANIC CORROSION _____ 870324

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PARTIAL FMC LTHD TELEPHONE DIRECTORY - 11/28/86

DEPT	NAME	612-572-	MAIL
ENG/ CONC DEV	BART ANDERSON	6070 786-945	C501
	DAVE BOUDREAU	6057 560-3055	C501
	SCOTT DACKO	6038 647-0390	C501
	JEFF IRELAND	7629 890-0749	C501
	DAVE LANGERUD	6322 636-2109	C301
	RON LARSON	7629 6341	C301
	ROBERT RATHE	6069	C501
	MARK RUMPSA	6347 788-2857	C501
	DIANE TOLLETTE	6341 7531	C501
	JOE TUREK	7623	C501
	TERRY WALTON	6341	C501
	DAVE WARWICK	7628 784-0205	C501
	KENT WILLIAMS	7686 424-6142	C501
	PATTY YELICH	7662 561-7089	C501
	TOM WASIK	7640	C501
ADV.	ELLEN BRADY	6380	C401
TECH/	DEBORAH FELLOWS	6331	C401
COMPO-	DAN MAGUIRE	6052	C401
SITES	LAUREN REZAC	6393	C401
	TOM RUDOLF	7500	C401
	BRUCE ZIERWICK	6394	C401
ADV.T./	STEVE FRENCH	6056	C401
METALS	PRANAB LAHIRI	6053	C401
MFG	FRED APPLETON	6352	C202
ENG	JIM WALLACE	6332	M430
APPL	JOHN GREEN	6072	C301
MECH	BOB MORTENSEN	6083	C301
	LEANNA PETERSON	7658	C301
	S. MARK, JES FISHBEIN	6075	C301
✓ STR	LARRY LIBHARDT	6027	C301
MECH	JIM RIES	7600	C301
SYS	TOM HILLSTROM	6024	C401
ENG	MIKE JANSSEN	7616	C401
	FLOYD MANSON	6017	C401
	ERROL QUICK	6001	C401
	BOB SCHMIDT	6344	C401
TEST	DAVE FLIPPO	3298	M415
QA/QC	LYMAN MALBERG	6491	M215
	MIKE LEMONE	3298	M415
ARDEC	ROB NITZSCHE	201-724-2085	
BENET	MALCOLM DALE	518-266-4162	
FMC/CHC	ADDRESS: FMC/NOD, 3RD FLOOR, 3989 CENTRAL AVE, MPLS, MN 55421		
F.E. #:	0554-01900		
PROG M.	DAVE PETERSON	6333	C202
BUS	BOB STRATTON	6338	C202
DEV	FMC/CHC TELECOPY	788-2951	C202

THOMAS VOLKMAN 6070

GARY NYSTUEN

GENE MARSHIK
V7623 421-5973

MYRON (MIKE) HASS 702

JOHN ADAM 649
M1215

JUDY LOBECK
3272

SCOT SHOFTE
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Torrington, Conn. 06790
(203) 482-9511

DIRECTORY (870317)

Darrel G. Turner
Supervisor
Composite Materials Production

MORTON THIKOL INC.
Wasatch Operations

Strategic Division
Box 504 Brigham City, Utah 84302
(801) 353-3924 M.S.R.



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RAY JONES
Regional Marketing Manager
P. O. Box C48
Cinnaminson, N. J. 08077
Phone (609) 829-7090

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TECHNICAL CENTER, AERON. DEPT. 44018
PHONE: (816) 788-8010

Frank Link
Government OEM Manager

MIDLAND

MIDLAND BRAKE, INC.
2702 North State Street, Iola, KS 66749

800-835-0
316-365-6

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 ALBEC (BWL)
 ATTN: STEAR-CCB-PA MALCOLM DALE
 WATERVLIET, NY
 12184-4050
 LIGHTWEIGHT TOWED HOWITZER KEY GOVERNMENT PERSONNEL

<u>NAME</u>	<u>POSITION</u>	<u>PHONE</u>	<u>AREA OF RESPONSIBILITY</u>
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THE FOLLOWING 10 PAGES INDEXES
DATA CONTAINED WITHIN A SUBFILE
CALLED "NUMBER" WITHIN THE LTHD
PROJECTIVE FILE. ORIGINALLY THE
LTHD DATA WAS FILED USING A
RANDOM ACCESS NUMBER SYSTEM.
LATER, INFO WAS STORED VIA A KEYWORD
ALPHA SYSTEM TO REDUCE USAGE COSTS.

THIS FILE CONTAINS THE ORIGINAL
DATA THAT WAS NOT TRANSITIONED
TO THE ALPHA SYSTEM.

Items circled in blue have been moved to ALPHA file

NUMBER	CALL NUMBER (SOURCE)	DESCRIPTION	LOCATION	OWNER	KEYWORD(S)
0		THIS INDEX. ALSO ON DISK (SEE NUMBER 45)	FROM FILE	PROJECT	INDEX
1	FM 6-40 (ARMY)	AMMUNITION AND BALLISTICS	FROM FILE	PROJECT	FIELD ARTILLERY MANUAL
2	FM 100-1 (ARMY)	ARMY PHILOSOPHY - NOTHING ON HARDWARE	FROM FILE	PROJECT	ARMY PHILOSOPHY
3	(SCOTT LANGLEY)	FMG GUN ANALYSIS CAPABILITIES	FROM FILE	PROJECT	BALLISTICS FIELD TANDEM HEATING MIDDLE BRACKET BORE EVACUATOR PROJECTILES PROPELLANTS
4	ADA 090386 (ARMY)	COMPOSITE GUN BARREL EXTENSION TEST 8	FROM FILE	PROJECT	COMPOSITE GUN
5	(SPACE RESEARCH)	SPACE RESEARCH STUDY ON 155 MM WEAPONS BARRELS, MIDDLE BRACKET, BORE EVACUATORS, PROJECTILES, PROPELLANTS	FROM FILE	PROJECT	TANDEM MIDDLE BRACKET BORE EVACUATOR PROJECTILES PROPELLANTS
6		COLLECTION OF ARTICLES ON TEMP AND LEAK REDUCTION OF CANNON	FROM FILE	PROJECT	CANNON WEAR CANNON HEATING
7	800770 (ARMY)	INTERFACE DRAWINGS FOR 155 MM ARTILLERY	FROM FILE	PROJECT	BALLISTICS PROJECTILES
8	MIL-H-45934487 (ARMY)	MICROFILM CARDS ON M156 RADIATING	BECHTEL	BECHTEL	M156 RADIATING
9	(ARMY)	155 MM ARTILLERY SUMMARY	FROM FILE	PROJECT	155 MM ARTILLERY
10	(ARMY)	COLLECTION OF ARM R&D REPORTS ON TOWED HOWITZERS	FROM FILE	PROJECT	M156 HOWITZER RECORD-807
11	(BRAC)	BRAC'S FILE: INCLUDES FMG COMPOSITE GUN STUDY AS WELL AS SEVERAL OTHER WEIGHT-SAVING IDEAS	FROM FILE	BRAC	COMPOSITE CANNON CONCEPTS
12		SURVEY OF HOWITZERS	FROM FILE	PROJECT	HOWITZERS
13	TM 9-1025-21-10 (ARMY)	OPERATOR AND ORGANIZATIONAL MANUAL FOR M114 155 MM HOWITZER, PREDECESSOR TO M156	FROM FILE	PROJECT	M114 HOWITZER
14	(ARMY)	HOWITZER, 155 MM, TOWED, M156 & ASSOCIATED AMMUNITION, THIRD EDITION, OCTOBER, 1979	FROM FILE	PROJECT	M156 MANUAL
15		SURVEY OF TOW VEHICLES USABLE WITH HOWITZERS	FROM FILE	PROJECT	HOWITZER TOW VEHICLES
16	84-001 (ARMY)	ANALYSIS OF FEASIBILITY OF M156 WEIGHT REDCN	FROM FILE	PROJECT	HOWITZER WGT ANALYSIS
17		SUMMARY OF BIDES COMPUTER SEARCHES	FROM FILE	PROJECT	INFORMATION SEARCH
18	75-DET-17 (ARMC)	FREE PISTON SUBSTITUTE FOR IMPACT DAMPER	FROM FILE	PROJECT	RECORD

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19		SURVEY OF RECOIL ANALYSIS METHODS USED FOR INDUSTRIAL AND AIRCRAFT APPLICATIONS	PROJ FILE	PROJECT	RECOIL
20	AMCP 706-342 (ARMY)	DESIGN HANDBOOK FOR RECOIL SYSTEMS	PROJ FILE	PROJECT	RECOIL
21	(ASLE)	SURFACE PROFILE REDUCES RECOIL BEARING WEAR	PROJ FILE	PROJECT	RECOIL BEARINGS
22	(ARMY)	COMPRESSIBLE FLUID RECOIL ELIMINATES SEPARATE RECUPERATOR	PROJ FILE	PROJECT	RECOIL
23		COLLECTION OF ARTICLES ON RECOIL FLUIDS	PROJ FILE	PROJECT	RECOIL FLUIDS
24		USE OF A SERVO SYSTEM TO SIMULATE CANNON FORCES	PROJ FILE	PROJECT	RECOIL CANNON FORCE SIMULATION
25		OPERATOR AND ORGANIZATIONAL MAINTENANCE MANUAL -HOWITZER, LIGHT, TOWED 105 MM SOFT RECOIL (XM204 MODEL AD)	PROJ FILE	PROJECT	RECOIL-SOFT
26		SURVEY OF COMPUTER PROGRAMS AVAILABLE	PROJ FILE	PROJECT	COMPUTER ANALYSIS
28		ITEMS REQUESTED FROM BUSINESS DEVELOPMENT	PROJ FILE	PROJECT	REQUISITIONS
29		NOTES FROM INFORMATION SEARCH	PROJ FILE	PROJECT	INFORMATION SEARCH
30	E246-1096 (GICER)	TEST PROVES WOMEN CAN RUN M198	PROJ FILE	PROJECT	M198 CREW
31	E224-2422 (GICER)	M198 NEEDS NARROWER TIRES FOR LOADING	PROJ FILE	PROJECT	M198 ENVELOPE
32	FT 155-AC-1 (ARMY)	155 MM FIRING TABLES	PROJ FILE	KRAMER	BALLISTICS
33		DESIGN AND DEVELOPMENT OF FIGHTING VEHICLES BY R. M. OGDENVIEWHICZ, C. 1968, DOUBLEDAY.	STAIERT	STAIERT	BALLISTICS
34		PHOTOGRAPHS OF HOWITZERS	PROJ FILE	KRAMER	HOWITZERS
35		LITERATURE REQUESTS (LIBRARY AND J SCHWENCK)	PROJ FILE	PROJECT	REQUISITIONS
36	MIL-M-45984 (AR) (ARMY)	M45 RECOIL PROCUREMENT SPECIFICATION	PROJ FILE	PROJECT	RECOIL
37	MIL-M-45984 (AR) (ARMY)	PROPOSAL OF A RECOIL PROCUREMENT SPECIFICATION	PROJ FILE	PROJECT	RECOIL
38	MIL-M-45984A (AR) (ARMY)	M198 PROCUREMENT SPECIFICATION	PROJ FILE	PROJECT	M198 PROCUREMENT SPEC
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404	AD-A001 007 (DTIC)	RISA ANALYSIS OF M458 BOTTOM CARRIAGE MADE OF MONOLITHIC ALUMINUM	PROJ FILE	PROJECT	M198 CARRIAGE WEIGHT REDUCTION
408	AD 756 357 (DTIC)	M198 RECOIL ANALYSIS SHOWS FEAK-TC-AVERAGE FORCE RATIO IS COMPROMISED BY VARIABLE STROKE.	PROJ FILE	PROJECT	M198 RECOIL RECOIL
410	AD A101 219 (DTIC)	US ARMY TEST AND EVALUATION PROCEDURES FOR RECOILLESS RIFLES	PROJ FILE	PROJECT	RECOILLESS

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400	(DTIC)	NOTES ON THE WEIGHTS OF GUNS, MORTARS, RECOILLESS WEAPONS, AND AMMUNITION	PROD FILE	KRAMEF	HOWITZERS
405	AD-A110115 (DTIC)	BLAST FIELD INVESTIGATIONS	PROD FILE	PROJECT	MUZZLE BRAKES
406	AD A058 888 (DTIC)	BORON/ALUMINUM LANDING GEAR FOR NAVY AIRCRAFT	PROD FILE	PROJECT	COMPOSITES
408	AD 769 041 (DTIC)	GRAPHITE COMPOSITE LANDING GEAR COMPONENTS	PROD FILE	PROJECT	COMPOSITES
409	AD A105 008 (DTIC)	ENERGY ABSORPTION OF COMPOSITE MATERIALS	PROD FILE	PROJECT	COMPOSITES ENERGY ABSORPTION
401	AD E406 088 (DTIC)	DEVELOPMENT OF 105 MM TOWED HOWITZER WITH SOFT RECOIL AND FIRE OUT OF BATTERY	PROD FILE	PROJECT	RECOIL-SOFT FIRE OUT OF BATTERY
401	AD A006 007 (DTIC)	GRAPHITE COMPOSITE AIRCRAFT LANDING GEAR W/L	PROD FILE	PROJECT	COMPOSITES WHEELS
411		PERTINENT MIL STDs			
412	MIL-STD-14743 (M)	NOISE LIMITS FOR ARMY MATERIEL	PROD FILE	PROJECT	MUZZLE BRAKES
421	(DTIC)	DTIC INFORMATION SEARCHES	PROD FILE	PROJECT	INFORMATION SEARCH
422	(DTIC)	TECHNICAL REPORT SUMMARY: SHOCK ABSORBERS	PROD FILE	PROJECT	RECOIL
423	(DTIC)	TECH REPORT SUMMARY: TRAVERSING MECHANISMS	PROD FILE	PROJECT	TRAVERSING MECHANISM
420	(DTIC)	TECH REPORT SUMMARY: ENERGY ABSORBERS	PROD FILE	PROJECT	RECOIL
421	(DTIC)	TECH REPORT SUMMARY: HOWITZERS	PROD FILE	PROJECT	HOWITZERS
425	(DTIC)	TECH REPORT SUMMARY: LANDING IMPACT	PROD FILE	PROJECT	RECOIL
427	(DTIC)	TECH REPORT SUMMARY: LANDING GEAR	PROD FILE	PROJECT	RECOIL
428	(DTIC)	TECH REPORT SUMMARY: GUN BARREL ATTACHMENTS	PROD FILE	PROJECT	MUZZLE BRAKES CANNONS
429	(DTIC)	HYDRAULIC POWER PORTABLE GENERATORS	PROD FILE	PROJECT	APU
43		PHOTOS OF HOWITZER EMPLACEMENTS IN VIET NAM	STAIERT	STAIERT	HOWITZER EMPLACEMENT
441		VENDOR LITERATURE AND MISC INFORMATION	PROD FILE	PROJECT	VENDOR LITERATURE
442		LONG STROKE CYCLE	PROD FILE	PROJECT	ELEVATING MECHANISM
442		HYDRAULIC POWER AND PORTABLE MILITARY GENERATORS	PROD FILE	PROJECT	APU
443		TIRES	PROD FILE	PROJECT	TIRES
441		SELF-ALIGNING SELF- LUBRICATING BEARINGS	PROD FILE	PROJECT	BEARINGS

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44F		HYDRAULIC VALVES POTENTIALLY CAPABLE OF HOLDING RECOIL FORCE CONSTANT	PROJ FILE	PROJECT	RECOIL VALVES
44G		POTENTIAL RECOIL BEARINGS	PROJ FILE	PROJECT	RECOIL BEARINGS
44H		POSITION TRANSDUCERS	PROJ FILE	PROJECT	POSITION TRANSDUCERS
44I		PANCAKE CYLINDERS	PROJ FILE	PROJECT	CYLINDERS
44J		COMPOSITE CYLINDERS	PROJ FILE	PROJECT	COMPOSITES CYLINDERS
44K		MUZZLE BRAKES	PROJ FILE	PROJECT	MUZZLE BRAKES
44L		ACCUMULATORS	PROJ FILE	PROJECT	METAL BELLOW ACCUMULATORS
44M		AIRCRAFT FOR HOWITZER TRANSPORTATION	PROJ FILE	PROJECT	HOWITZER AIRLIFT VEHICLES AIRCRAFT
45A		PROJECT INFORMATION STORED ON DISK	ANDERSON	PROJECT	COMPUTER FILES
45B		PROGRAM TO CONVERT RECOIL OUTPUT TO RECOIL TABLE INPUT. NAME = LKTH45A			
45C		INFORMATION ACQUIRED THRU DISCUSSIONS WITH BOB SCHMIDT	PROJ FILE	PROJECT	HOWITZERS
47A		REQUEST FOR INFORMATION PROCEDURES, EXAMPLES, AND NOTES.	PROJ FILE	PROJECT	INFORMATION SEARCH REQUEST FOR INFORMATION
47B		RFI ON RECOIL SYSTEMS (ALSO ON DISK, SEE #45)	PROJ FILE	PROJECT	RECOIL
47E		SPEED SHIFT CYLINDER	PROJ FILE	PROJECT	CYLINDER
48		SUMMARY OF M198 SPECS. ALSO ON DISK, SEE #45	PROJ FILE	PROJECT	M198 SPECIFICATIONS
49		LIGHTWEIGHT HOWITZER IDEA LIST	PROJ FILE	PROJECT	CONCEPTS
50-A		LIGHTWEIGHT HOWITZER SYSTEM CONCEPTS	PROJ FILE	PROJECT	CONCEPTS
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50-2		CONCEPT 2	PROJ FILE	PROJECT	
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50-E		CONCEPT 5: SPACE FRAME	PROJ FILE	PROJECT	SPACE FRAME RECOIL ELEVATING MECHANISMS
51		COMPUTER RUNS FROM PROGRAM "RECOIL"	PROJ FILE	PROJECT	RECOIL PROGRAM RUNS COMPUTER ANALYSIS
52		MEETINGS AND PLANS (BY DATE)	PROJ FILE	PROJECT	PLAN MEMO MEETINGS
53		TRIP TO RIA 840908	PROJ FILE	PROJECT	M198 HOWITZER TRIPS
54		COMPUTER RUNS FROM PROGRAM "INTEAL"	PROJ FILE	PROJECT	BALLISTICS COMPUTER ANALYSIS INTEAL
55		BRAINSTORMING SESSION OF 840910-14 WITH CEL	PROJ FILE	PROJECT	BRAINSTORM CONCEPTS RECOIL
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58		MARKETING INTELLIGENCE REPORTS	PROJ FILE	PROJECT	INTELLIGENCE
59		RHEINMETAL HANDPOD (BLUE)	RATHE	FMC	WEAPON DESIGN
60	MF-6-5997	(ARMY) M198 TRAINING FILM	FORN RECD	APM	M198 TRAINING FILM FILMS
61	E156-2406	(GIDEF) ANALYSIS OF A COMPRESSIBLE FLUID SOFT RECOIL (CFSR) FOR 155 MM HOWITZER	PROJ FILE	PROJECT	RECOIL-SOFT
62A		LIGHTWEIGHT HOWITZER - COMPONENT CONCEPTS	PROJ FILE	PROJECT	CONCEPTS
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65A		FILM			
65B		NARRATIVE TEXT			
66	TM 9-1025-211-10	(ARMY) M198 OPERATOR'S MANUAL, CREW, OCT 75	PROJ FILE	PROJECT	M198 MANUAL

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67	TM 9-2265	(ARMY) PRINCIPLES OF ARTILLERY WEAPONS	PROD FILE	PROJECT	HOWITZER RECOIL ARTILLERY
68	ESPAWE	(FMC) ENHANCED SELF-PROPELLED ARTILLERY WEAPON SYSTEM			
68A		VOL 1 - TECHNICAL REPORT APPENDICES EXCEPT D, SECTIONS AND F	Schematic	FMC	RECOIL MUZZLE BRAKES BALLISTICS BREECHES CANNONS
68B		VOL 1 - TECH REPORT CH 3 (EXC 3.2), 5-8			
69	FE-70-2442	EXPERIMENTAL INVESTIGATION OF MUZZLE BRAKES FOR XM198 HOWITZER. JAN 70. SALSBURY, SPAFFER, ARTILLERY SYSTEMS LAB, ROCK ISLAND, IL.	PROD FILE	PROJECT	MUZZLE BRAKES
70	OF 2552	(NABA) ELECTRONIC CONTROL FOR AN ELECTROHYDRAULIC ACTIVE CONTROL LANDING GEAR FOR THE F-4	PROD FILE	PROJECT	VALVES SERVO CONTROL
71		CEU SUPPORT OF PROJECT	"	"	CEU WORK
72		(FMC) JEFF IRELAND: WORKING PROGRAM TO CALCULATE RECOIL OFFICE AREA FOR SCOT CONCEPT	MAIN X6771	—	RECOIL
73	TM 9-1025-211-202P (ARMY)	ORGANIZATIONAL MAINTENANCE MANUAL INCLUDING ASSEMBLY PARTS AND SPECIAL TOOLS FOR M198	PROD FILE	PROJECT	M198 MAINT

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MIL-STD-810D

ENVIRONMENTAL TESTS, METHODS
AND ENGINEERING GUIDELINES

MIL-STD-210

~~WATER~~ AMBIENT DATA
CLIMATIC EXTREMES
FOR MILITARY EQUIP.

AR 70-38

TESTING MATERIALS FOR
CLIMATIC CONDITIONS

S

MIL-STD-810D
19 July 1983

SPECIFICATIONS

MILITARY

~~MIL-STD-901~~

Shock Tests, H.I. (High Impact), Ship Machinery, Equipment And Systems

STANDARDS

MILITARY

~~MIL-STD-107~~

~~MIL-STD-210~~

~~MIL-STD-201~~

Mechanical Vibrations Of Shipboard Equipment
Climatic Extremes For Military Equipment
Reliability Testing For Engineering Development,
Qualification And Production

~~MIL-STD-1165~~

Glossary Of Environmental Terms

~~MIL-STD-1540~~

Test Requirements For Space Vehicles

~~MIL-STD-1670~~

Environmental Criteria And Guidelines For Air-Launched Weapons

~~MIL-STD-1762~~

Calibration System Requirements

PUBLICATIONS

~~AR 70-38~~

Research, Development, Test And Evaluation Of Materiel For Extreme Climatic Conditions

~~STANAG 2831~~

Climatic Environmental Conditions Affecting The Design Of Materiel For Use By NATO Forces Operating In A Ground Role

~~STANAG 3545AL~~

Environmental Test Methods For Aircraft Equipment And Associated Ground Equipment

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 The following definitions shall apply:

a. Accelerated test. A test designed to shorten the test time by increasing the frequency or duration of environmental stresses that would be expected to occur during field use.

b. Aggravated test. A test in which one or more conditions are set at a more stressful level than the test item will encounter in the field in order to reduce test time, reduce sample sizes, or assure a margin of safety.

c. Ambient environment. The conditions (e.g., temperature and humidity) characterizing the air or other medium that surrounds materiel.

d. Environmental conditions. (see Forcing function).

DESCRIPTION: WHO-WHAT LIST

STATUS: A list of "who does what" and estimates of hours required for Phase II completion was developed with input from the project participants.

The information is current and complete as of 12 March 1987 with minor changes.

AUTHORS: FMC/NOI team members.

Phase 2 Tasks Remaining

Barl Anderson

Critical Path management of design.....
 Master Schedule.....
 York.....
 Marotta.....
 Torrington.....
 Unassigned items.....
 Front slide manifold to replacement (swivel up) skid plate.....
 Finish hydraulic system detailing (with Dave, Jeff, Joe, Scott) and stay abreast of changing.....
 Inter-team support.....
 Equilibration mounting tube (work with Gene).....

Bob Mortenson

Bob Schmidt

Charles Ortloff

Start system model update (coordinate with Larry).....
 Finish model runs (coordinate with Larry).....
 Organize Appendix of raw data (with Larry).....
 Provide text cover for Appendix (coordinate with Larry).....

Charlie Baliside

Audit recoil and hydraulic system analysis..... ??? ??...120

Dan McGuire

Structural analysis of

Speedshift swivel (work with Kent)..... ??? ??...12
 Load ways and load way mounting (work with Ron)..... ??? ??...100
 Load tray (work with Ron)..... ??? ??...136
 Load way mounting (work with Ron).....
 Fire control mounts and links (work with Scott)..... ??? ??...40
 Load tray walking beams and ramming actuator trolley (work with Ron)..... ??? ??...20
 Inter-team support.....

Dave Boudreau
Critical path management of Ph 3 hardware

Long lead item list..... May 04.....30

Critical path item Gantt charting..... Mar 04

Tailights and wiring..... Mar 23.....8

Generate cash flow curves for critical path items (committed & sunk \$)..... May 01.....24

Rasrod critical path hardware drawings.....

Add drawing status to PH-log..... Mar 04

PH-log..... May 01.....64

Muzzle brake..... May 01.....28

Coordination of design practices and checking of all drawings..... AR

Complete Assy reqs - general..... May 01.....8

Book of project specs..... May 01.....24

Spare parts.....

Standard Document Book..... Apr 30.....14

Finish off walking beams..... May 01.....28

Inter-team support.....

Dave Flippo
Ph 3 costs for structural testing (where?)..... 77 77.....16

Dave Langerud
Platform weldment and machining

Make sure part is good from sig viewpoint..... 77 77.....4

Complete analysis..... 77 77.....160

Note final revisions and prepare dgs for release..... 77 77.....4

Spade calcs, sig review, revs)..... 77 77.....20

Siabal design support..... Mar 14.....40

Allow for racking of platform.....

Finalize analysis and revise dgs (loads per Jeff)..... Mar 21

Drawings to orloff..... Mar 21

Finish contribution to final stress analysis report..... Mar 27

Platform..... 77 77.....160

Spade..... 77 77.....16

Inter-team support..... Apr 17.....60

Dave Marwick
Recoil cylinder dgs (revise)..... 77 77.....4

Mid-manifold mounting (layout, detail, revs)..... 77 77.....44

Siabal manifold, hoses, and hardline (layout, detail, revs)..... 77 77.....144

Tube bundles on cradle (layout, calcs, detail, revs)..... 77 77.....92

Compound actuator drawings (layout and revs)..... 77 77.....68

Finish hydr syst detailing (incl revs)..... 77 77.....88

Midslide manifold to detailing..... Feb 27

Integrate York and Marotta revs..... Mar 20.....40

MSM corrections to Judy..... 77 77.....40

Finish hydraulic system detailing (with Bart, Jeff, Joe, Scott) and stay abreast of chng.....

Inter-team support.....

Diane Jollette
 Trail (with Lauren, Suellen)..... 378
 Swivel tie-in to cradle..... 100
 Structural analysis report..... 40
 Plastics applications: trail pads, load tray guides, and etc per Mark..... 294
 Inter-team support.....

Ellen Brady
 Test plan..... 40
 Contractor developed specs..... 120

Fred Appleton
 Assy at BCF or MP?.....
 Charge number for weld piece parts.....

Gary Mystuen
 Checking of drawings.....
 Walking Beams..... May 01...30
 Platform..... 80
 Spade..... 12
 Trails..... 40
 Trail swivel tie-in to platform..... 18
 Plastic parts..... 16
 Inter-team support.....

Gene Marshik
 Front slide manifold and all attachments to it, ready to detail..... Mar 30...230
 Revisions..... 180
 Lifting eyes for FSM (with Scott).....
 Integrate York and Harotta revs..... Mar 20
 Inter-team support.....

Jeff Ireland
 Complete hydraulic system design and analysis..... Mar 05
 Review Harotta dwgs and work out rest of problems.....
 Work with Charlie on audit.....
 Finish hydraulic system detailing (with Bart, Dave, Joe, Scott) and stay abreast of chng.....
 Inter-team support.....

Jim Ries (11 hrs @ 8 hrs/wk = 90)
 Attend status mtgs..... May 16...90
 Misc analyses.....
 Manage analysis activities.....

Jim Wallace
 Make/Buy.....
 Source selection of critical composite parts.....
 Ph 3 costs.....

Joe Fishbine
 Optimize stress analysis of collars.....
 Titanium bulkhead joint analysis.....

11thd disk 17, whowhat, 23Feb87

Joe Turek
 Cannon GFE to Benet/ARDEC (with Joe)..... Feb 25
 Finish autopriar mount (with Tie)..... Mar 04
 Finish balance of cannon assembly..... Mar 18
 Design band travel support.....
 A2/OE alignment tool spec.....
 Finish hydraulic system detailing (with Bart, Dave, Jeff, Scott) and stay abreast of chng.....
 Assist in detailing and checking.....
 Inter-team support.....

John Green
 Final equilibration/elevation analysis.....
 Prepare Appendix for inclusion in DAR (work with Scott).....
 Prepare text for DAR (work with Scott).....

J.R. Tousley
 Judy Lobeck
 Check MSM for port intersections and wall thicknesses.....
 Detail MSM.....
 Check FSM for port intersections and wall thicknesses.....
 Detail FSM.....

Kent Williams
 Design of cradle and all interfaces.....
 Finalize all bearing joint designs.....
 Quantitative integration.....
 Mass distributions.....
 Speedshift assembly.....
 Inter-team support.....

5

Larry Libhardt		
Larry (11 hrs @ 40 hrs/wk)		May 16.....440
Manage analytical activities		
Document analysis effort		
Perform misc analyses		
Present results to ardec		
MCR (cradle analysis)		
3 static iterations; 8 hrs@70/hr rel. 12x3=\$1880		77 77.....\$ 1,880
2 transient iterations; 6 hrs@70/hr rel. 12x2=\$940		77 77.....\$ 940
Plots and misc expense		77 77.....\$ 300
Misc		77 77.....\$ 380
CEL		
Final analysis (180 hrs @ 80/hr)		.....\$15,000
Upgrade model to final configuration		
Run one transient analysis		
Post process and evaluate results		
Write report		
Direct stress analysis on cradle		
Audit all stress analysis		
Support source selection of critical composite components		
Start system model update (work by Charles)		
Finish model runs (work by Charles)		
Organize Appendix of raw data (work by Charles)		
Provide Text Cover for Appendix (work by Charles)		
Prepare stress analysis report (with Scott)		
Inter-team support		
Lauren Rezac		
Trail (with Diane, Suellen)		
Speedshift peg		
Inter-team support		
Lyann Walberg		
Quality Program Plan		77 77.....80
Mark Rodascher		
Mart Ruspaa		
Siabal		
Functional		
Qualitative Integration		
Prepare TDP		Apr 01
Inter-team support		
Marotte		
Provide approval prints for all subassemblies		
Provide Ph 3 cost estimate and delivery schedule		
Mike Haas		
Mike Janssen		
Reliability Analysis		77 77.....147

Patty Velich
 Siabal to afg..... Mar 06
 Inverse bracket outline dwg/sketch..... Mar 09
 Finalize analysis and revise dwgs (loads per Jeff)..... Mar 21
 Drawings to orthoff..... Mar 21
 Finish contribution to final stress analysis report..... Mar 21
 Inter-team support..... Mar 27

Rob Mitzsche
 Fire control hardware.....
 Will 8-size copies serve for end-of-Ph-2 review, or are aylars req'd.....
 Will ARDEC supply inner band.....
 Will titanium muzzle brake be approved.....

Robert Rathe
 Resolve issues with Rob.....

Ron Larson
 Loading system..... Mar 04
 Fire control (with Scott)..... Mar 27
 Mount hand pumps and joysticks (with Scott).....
 Detail all loading system and fc items (with Scott).....
 Inter-team support.....

Scott Dacko
 Cannon GFE to Benet/ARDEC (with Scott)..... Feb 25
 Coordinate quotes on ALSiC materials.....
 Current system stability from battery & load pos in grd & against curb to ARDEC..... Mar 02
 Fire control assembly (with Ron)..... Mar 27
 Mount hand pumps and joysticks (with Ron).....
 Design and integrate lift tie-down points on platform..... Feb 28
 Lifting eyes on FSM (with Gene).....
 Make sure operational concerns aren't overlooked during design..... AR
 Make sure proprietary data agreements are in place..... AR
 Finish hydraulic system detailing (with Bert, DaveM, Jeff, Joel and stay abreast of chng.....
 Prepare Dynamic Analysis Report.....
 Prepare Stress Analysis Report (with Larry).....
 Detail drawings of nameplates.....
 Inter-team support.....

Scott Shjette
 Sean Marek
 Determine critical parameters of lay control valves.....
 Prepare Appendix for DAR (work with Scott).....
 Prepare writup of analysis for Dynamic Analysis Report.....

Suellen Halverson
 Trail (with Diane, Lauren).....
 Spade.....
 Inter-team support.....

Terry Gottwaldt

lthd disk 17, whowhat, 23feb87

Tim Doehring	Auto primer (with Joe).....	
Tom Hillstrom	Preliminary Hazard Analysis Report.....	16
Tom Rudolf	Stay abreast of composite component activity and watch for problems/opportunities.....	
	Determine which components should be made at MOD.....	
	Inter-team support.....	
Tom Volkman	Complete analysis of reaming system.....	
	Check porting logic, structurally analyze, and minimize weight of MSM.....	
	Check porting logic, structurally analyze, and minimize weight of FSM.....	
	Prepare Appendix sections for DAR (work with Scott).....	
	Prepare Appendix sections for Stress Analysis Report (work with Scott).....	
	Prepare text for DAR (work with Scott).....	
	Prepare text for Stress Analysis Report (work with Scott).....	
	Inter-team support.....	
Tom Wasik	Platform.....	
	Cradle.....	
	Inter-team support.....	
Unassigned	Test of composites	
	QA/QC of composites	
	Spec control dng for APU	
	Basic issue items and carrier	
	Preparation for cdr	
	Equilibrator link ass'y	
	MSM mounting pads	
	cradle torque anchors	
	Ph 3 engrng resp	
	trail foot ass'y	
	Weight reduction opportunity search	
	Trail hardware to FSM	
	Trail hdwe to platform	
	Tailights and wiring	
	Employ directional properties in composites	
	Update F80's	
	Add fatigue	
	Composites spreadsheet	
	Design trail with one lattice knocked out?	
Unanswered questions (that may never be answered)		
	Will outer band self-center?	
	Should seal Ti parts be heat treated to 150 ksi (bulhead, ab s1)?	
	Will a propo carrier be needed?	
	How much energy can be recovered by firing a I7 or I85 without propo?	
	Mug Logo?	
	Comparisons btwn Ti and stl for ab (Bob Mortenson).....	

(PAGES 9-12)
DO NOT
EXIST

York

Provide approval prints for all assemblies.....
Revise prints per markups.....
Submit complete print package.....
Submit Appendix of raw data from structural analysis.....
Submit Appendix of raw data from non-structural analysis.....
Provide test supporting structural analysis.....
Provide test supporting non-structural analysis.....
Provide Ph 3 cost estimate and delivery schedule.....

Phase 3 tasks Remaining

Dave Boudreau
Brate system bracket mod

11th disk 17, whowhat, 23feb87

NAME EUBANK

DATE 2-3-89

ASSEMBLY NUMBER

ASSEMBLY NAME

ALL STANARDS Parts DWGS (New Printing)

TASKS REQ D TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/ /MO)

ESTIMATE OF ADD L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME CHARLIE DALYDE

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME AUDIT REOR & HYD SYSTEM ANALYSIS.

TASKS REQ D TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/ /MO)

ESTIMATE OF ADD L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

THIS IS FIRST PAGE OF
BACK-UP DATA TO MASTER
SCHEDULE FOR PHASE II COMPLETION.

12

13

(PAGES 9-12)
DO NOT EXIST

NAME DAN MACGUIRE (with Kent)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME SPEEDSHIFT SWIVEL - STR. ANALYSIS

TASKS REQUIRED TO FINISH ASSEMBLY

LAYOUT

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAILING

PARTS LIST TASKS

CALCULATING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REVIEW (SHORT)

CHECKING TIPS OF SOMEONE ELSE'S TIME

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYSIS-
ESTIMATE

NAME DAN MAC GUIRE

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME EQUILIBRATION MTG TUBE - STR ANALYSIS

TASKS REQUIRED TO FINISH ASSEMBLY

LAYOUT

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAILING

PARTS LIST TASKS

CALCULATING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REVIEW (SHORT)

CHECKING TIPS OF SOMEONE ELSE'S TIME

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYSIS-
ESTIMATE

58 Std,
0 hrs

NAME DAN MACGUIRE (WITH ROW)

DATE 87-2-26

ASSEMBLY NUMBER

AGENCY NAME LOAD TRAY - STR ANALYSIS

TASKS REQUIRED TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

TOTAL

YOUR ANALYSIS/CALC S

REMAINING

EST. NO. OF DETAIL DRAWS

PARIS LIST TASKS

CALC/ASSIGNING OF ALL PART NO S

ASSIGNING OF ALL PART NO S

DESIGNING OF PARTS

CHECKING THEO OR SOMEONE ELSE S T

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (MM MO)

ESTIMATE OF AGENT ANALYSIS NEEDS

TRAY

ANALYST'S HR
ESTIMATE

16

NAME DAN MACGUIRE (WITH ROW)

DATE 87-2-26

ASSEMBLY NUMBER

AGENCY NAME STR ANALYSIS OF LOADWAYS & LOADWAY MTG

TASKS REQUIRED TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

TOTAL

YOUR ANALYSIS/CALC S

REMAINING

EST. NO. OF DETAIL DRAWS

PARIS LIST TASKS

CALC/ASSIGNING OF ALL PART NO S

ASSIGNING OF ALL PART NO S

DESIGNING OF PARTS

CHECKING THEO OR SOMEONE ELSE S T

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (MM MO)

ESTIMATE OF AGENT ANALYSIS NEEDS

TRAY

ANALYST'S HR
ESTIMATE

17

NAME DAN MACGUIRE (WITH SCOTT)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME STR ANALYSIS OF FIRE CONTROL MOUNTS & LINKS

TASKS REQUIRED TO
FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DINGS

PARTS LIST TASKS

CALCULATING OF ALL PARTS

ASSIGNING OF ALL PART NO'S

REWORKING OF ALL PARTS

CHECKING THINGS OF SOMEONE ELSE'S TIME

OTHERS

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HP
ESTIMATE

NAME DAN MACGUIRE (WITH RON)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME STR ANALYSIS OF CONDUIT WALKING BEAMS

TASKS REQUIRED TO
FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DINGS

PARTS LIST TASKS

CALCULATING OF ALL PARTS

ASSIGNING OF ALL PART NO'S

REWORKING OF ALL PARTS

CHECKING THINGS OF SOMEONE ELSE'S TIME

OTHERS

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HP
ESTIMATE

AD-A183 982

LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87

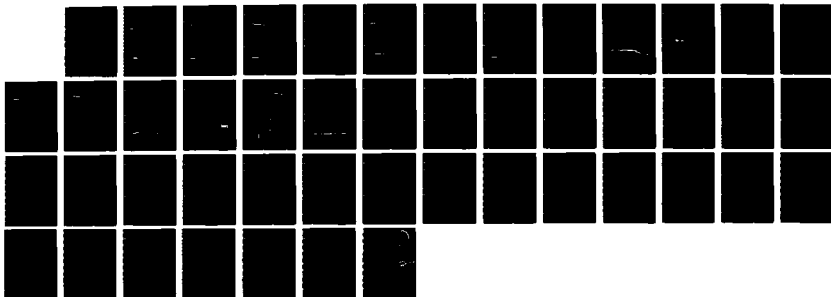
4/4

UNCLASSIFIED

FMC-E-3841-VOL-A DAAA21-86-C-8847

F/G 19/6

NL





NAME DAN MACGUIRE (WITH BEN)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME STR. ANALYSIS OF

included in *try walking beam*

TASKS REQUIRED TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK

AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DNGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REF/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS

ANALYST'S HR

ESTIMATE

NAME

DAVE

DATE

2/26

ASSEMBLY NUMBER

5-115

ASSEMBLY NAME

Doc. Book

TASKS REQ'D TO

FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DNGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REF/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS

ANALYST'S HR

ESTIMATE

NOT STARTED

NAME LOUARRAU

DATE 2/26

ASSEMBLY NUMBER 5710-485

ASSEMBLY NAME LONG LEAD

TASKS REQ'D TO
FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART MTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

TASKS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

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CALC/ASSIGNING OF ALL PART MTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME BOJOREAU

DATE 2/26

ASSEMBLY NUMBER 5710-5

ASSEMBLY NAME TRILLIGHT WIRING

TASKS REQ'D TO
FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART MTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

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REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME Boudreau

DATE 2/25

ASSEMBLY NUMBER 5710 - 620

ASSEMBLY NAME WALKING BEAMS

650 - 675

WALKING BEAMS

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

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YOUR ANALYSIS/CALC'S

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REVISIONS (SHORT)

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ESTIMATE OF ADD'L ANALYSIS NEEDS:

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ANALYST'S HR
ESTIMATE

NAME

DATE

ASSEMBLY NUMBER

ASSEMBLY NAME

TASKS REQ'D TO
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CHECKING (HRS OF SOMEONE ELSE'S TIME)

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OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME Boudreau

DATE 2/26

ASSEMBLY NUMBER 5710 - 75

ASSEMBLY NAME WTS NOT UCL IN LTHO

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DMGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NO'S

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

COMPLETED

24

25

NAME BORDREAU

DATE 2/26

ASSEMBLY NUMBER 5710-135

ASSEMBLY NAME ASY DEPT'S GCN

TASKS REQ'D TO FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER? COMPLETE

TOTAL HOURS TO FINISH TASK 8

EST. COMPLETION DATE (WK/MO) 5-1

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

NAME BORDREAU

DATE 2/26

ASSEMBLY NUMBER 5710-225

ASSEMBLY NAME BONE SYSTEM

TASKS REQ'D TO FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER? BACKLOG MODIFIED BY 14

Phase 3

TOTAL HOURS TO FINISH TASK 0

EST. COMPLETION DATE (WK/MO) -

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

COMPLETE

NAME Bureau

DATE 2/26

ASSEMBLY NUMBER 5710-561

ASSEMBLY NAME SPARE PARTS

TASKS REQ'D TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER? Compare List 24

TOTAL HOURS TO FINISH TASK 24

EST. COMPLETION DATE (W/MO) 5-1

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

NAME Bureau

DATE 2/26

ASSEMBLY NUMBER 5765-5066

ASSEMBLY NAME MUZZLE BRAKE

TASKS REQ'D TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER? JAWBOX INSIDE 24

TOTAL HOURS TO FINISH TASK 28

EST. COMPLETION DATE (W/MO) 5-1

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

NAME BOURDEAU

DATE 2/26

ASSEMBLY NUMBER 5710 - 15

ASSEMBLY NAME PARTS LIST

TASKS REQ'D TO FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER? Update and maintain

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

24

40

64

5-1

1

30

NAME DAVE BOURDEAU

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME GENERATE CAM FLOW CURVES for CRITICAL PATH ITEMS

TASKS REQ'D TO FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER? Invo. Generation

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

8

16

24

5-1

31

NAME Boudreau

DATE 2/26

ASSEMBLY NUMBER 5710 - 10

ASSEMBLY NAME GANTT CHARTS

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DAYS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK: ANALYST'S HR
ESTIMATE

NAME Boudreau

DATE 2/26

ASSEMBLY NUMBER 5710 - 850

ASSEMBLY NAME BOOK OF 120 SPEC

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DAYS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK: ANALYST'S HR
ESTIMATE

SGO'S EST: 467

NAME DAVID FLIPPO

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME PHASE 3 COSTS FOR STRUCTURAL TESTING

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PARTS

ASSIGNING OF ALL PART NO'S

WFG/HAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 46

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

NAME DAVID LANGERUD

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME PLATFORM

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NO'S

ASSIGNING OF ALL PART NO'S

WFG/HAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 248

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

Detailed Layout Level II DWG But not checked Does not include Analysis OR CHECKING 2-28-87

Design Calcs

Final Report

160

Maybe Reduced IF System's Analysis and Test Report Satisfy A Dec

2-26-87
DSL

NAME DAVE LANGERUD
DATE 87-2-26
ASSEMBLY NUMBER
ASSEMBLY NAME ~~SPADE~~ & SPADE

Weldment & Machinery Dwg

TASKS REQ'D TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS. 206 LBS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

Design Calcs
Final Report

ANALYST'S HR ESTIMATE

Detailed layout Level II Dwg. Calcd But Not checked. Does not include analysis or checking. 2-28-87

may be reduced if system's analysis and test report satisfy ARDEC

DSL
2-26-87

NAME DAVE LANGERUD
DATE 87-2-26
ASSEMBLY NUMBER
ASSEMBLY NAME ~~SPADE~~ & SPADE

TASKS REQ'D TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

Support Gimbal Design thru March 14

Inter-team Support thru April 17

ANALYST'S HR ESTIMATE

40 Hrs

60 Hrs

DAVE WARWICK

time

	layout	calc's	detail	rev's.	totals
recoil cyl. dwgs. from el. data comp.				4	
manifold hard lining w/ hoses	40	28	16	8	
compound act. dwgs. by 108 10/10/50	60			8	
mid-manifold mounting from 108/10/50	8		32	4	
global manifold w/ hoses	72		60	12	
finish hydraulic syst. det. from 108/10/50	80			8	
	260	28	108	44	

Int Y/M Revs.
for to Y/M
M3 M 108/10/50 detailing 100%
100% to 108/10/50

NAME DAVE WARWICK

DATE 87-2-26

ASSEMBLY NUMBER 5710-555

ASSEMBLY NAME RECOIL CYLINDER ASSY DWGS

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

4.00

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME DAVE WARWICK

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME FSM TO MSM HARDLINE & MSM TO CHAMBER 1 MOUNTED BRADLE

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

80

YOUR ANALYSIS/CALC'S

10

DETAILING

10

EST. NO. OF DETAIL DWGS

1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

8

ASSIGNING OF ALL PART NO'S

1

WFG/MAT'L REVIEW (SHORT)

1

CHECKING (HRS OF SOMEONE ELSE'S TIME)

1

REVISIONS (SHORT)

2

OTHER

1

TOTAL HOURS TO FINISH TASK

86

EST. COMPLETION DATE (WK/MO)

1

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

40

1

NAME DAVE WARWICK (WITH MARK)

DATE 87-2-26

ASSEMBLY NUMBER S710-275

ASSEMBLY NAME COMPOUND ACTUATOR Assy DWGS

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

20

YOUR ANALYSIS/CALC'S

10

DETAILING

10

EST. NO. OF DETAIL DWGS

1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

1

ASSIGNING OF ALL PART NO'S

1

WFG/MAT'L REVIEW (SHORT)

1

CHECKING (HRS OF SOMEONE ELSE'S TIME)

1

REVISIONS (SHORT)

3

OTHER

1

TOTAL HOURS TO FINISH TASK

25

EST. COMPLETION DATE (WK/MO)

1

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

41

1

NAME DAVE WARWICK

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME MID-MANIFOLD MOUNTING HARDWARE

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT 3

YOUR ANALYSIS/CALC'S 32

DETAILING 32

EST. NO. OF DETAIL DWGS 4

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT) 2

OTHER

TOTAL HOURS TO FINISH TASK 42

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME DAVE WARWICK

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME HOSES TO GIMBAL JUNCTION MANIFOLD & GIMBAL JUNCTION MANIFOLD

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT 40-5-1

YOUR ANALYSIS/CALC'S 10

DETAILING 60

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

42

43

NAME DAVE WAPUKX (WITH BROT, JEFF, JOE, SCOTT)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME FINISH HYD. SYS DETAILING

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

44

NAME DIANE TOLLETTE (WITH L. J. KAHN, SUELLER, KENT)

DATE 87-2-26

ASSEMBLY NUMBER 5710-595

ASSEMBLY NAME TRAIL ASSEMBLY

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

See Joe H. Layton

45

NAME DIANE TOULETTE

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME SWIVEL TIE-IN TO CRACK

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT 10

YOUR ANALYSIS/CALC'S 8

DETAILING 56

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS 1/2

ASSIGNING OF ALL PART NO'S 2

MFG/MAT'L REVIEW (SHORT) 4

CHECKING (HRS OF SOMEONE ELSE'S TIME) 18

REVISIONS (SHORT) 8

OTHER?

TOTAL HOURS TO FINISH TASK 118

EST. COMPLETION DATE (WK/MO) 4/3

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

46

NAME TOULETTE

DATE 2/26

ASSEMBLY NUMBER 5710 - 820

ASSEMBLY NAME BOOK OF STRUC ANALYSIS

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT 0

YOUR ANALYSIS/CALC'S 0

DETAILING 24

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS 4

ASSIGNING OF ALL PART NO'S 4

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME) 0

REVISIONS (SHORT) 5

OTHER?

TOTAL HOURS TO FINISH TASK 22

EST. COMPLETION DATE (WK/MO) end of phase II

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

47

NAME DIANE TOLLETTE

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME PLASTICS APPLICATIONS

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

40

YOUR ANALYSIS/CALC'S

40

DETAILING

80

EST. NO. OF DETAIL DWGS

10'S

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PARTS

20

ASSIGNING OF ALL PART NO'S

2

MF5/MAT'L REVIEW (SHORT)

5

CHECKING (HRS OF SOMEONE ELSE'S TIME)

10

REVISIONS (SHORT)

3

OTHER?

TOTAL HOURS TO FINISH TASK

200

EST. COMPLETION DATE (WK/MO)

2/5

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME ELLEN GRADY

DATE

ASSEMBLY NUMBER

ASSEMBLY NAME

MAT'L TESTING

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

10

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MF5/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME GENE MARCHIK

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME FRT CLIBE MANIFOLD & ALL ATTACHMENTS TO IT

TASKS REQ'D TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

4 hrs (until end of March)

YOUR ANALYSIS/CALC'S

DETAILING

N/A

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NTS

ASSIGNING OF ALL PART NOS

WFS/MAT L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S WORK)

REVISIONS (SHORT) NOT

OTHER

+

MANIFOLD

MRS

OTHER MRS

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK./MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

JIM RIES

2/27/87

Remaining Analysis Effort 3/1/87 - Completion Phase 2

MCR Assoc. / Cradle Analysis

Remaining, Renewal Costs

3 Static Iterations

$8 \text{ HRS} \times 70 / \text{HR} \times 1.12 \times 3 = \1880

2 Transient Iterations

$16 \text{ HRS} \times 70 / \text{HR} \times 1.12 \times 2 = \940

Plots & Misc Exp = \$300

Total \$ 3120

Assume \$ 3500

CEL / Outflow / Full System Transient Analysis

- Remaining Tasks will take 80 hours
- Upgrade model to final design configuration
 - Execute model for 1 Transient Analysis (e.g. 1 Barrel Orientation)
 - Post Process & Evaluate Results
 - Write Report

Cost = $180 \text{ HRS} \times \$80 / \text{HR}$

\$15,000

52

53

Larry Luthard Activities

Work Full Time on Project 31 WKS (THRU 5/16/87)

- Manage Analytical Activities
- Document Analytic Effort
- Perform Misc. Analyses
- Present results to ARDEC

$$11 \text{ Wks} \times 40 \text{ HRS} = \boxed{440 \text{ HRS}}$$

James Ries Activities

Work Part Time 11 WKS (THRU 5/16/87)

- Attend Status Mtg's
- Misc Analysis
- Manage Analytical Activities

$$11 \text{ Wks} \times 8 \text{ HRS/WK} = \boxed{90 \text{ HRS}}$$

30 HRS
5/11/87

Joe Frishben

Misc Activities

- Cradle Exam 60
- Elevation Gpt. Attachment 16
- Rear Manifold Attachment 16
- Trail Attachment to Platform & Trail Lock 32
- Trail Bulkhead 16

$$\text{Sub-total} = 140 \text{ HRS (EXCLUDING MANIFOLD)}$$

FWD MANIFOLD
MID MANIFOLD

COST PER MANIFOLD

- 160 HRS MODEL & RUN
- 40 HRS Reduce Wt / Re model
- 300 HRS / MANIFOLD
- + 5 Computer Runs / MANIFOLD (60 Min / Run @ \$700 / Run)
- 5 x 700 = \$3500 / MANIFOLD

$$\begin{aligned} \text{Cost For 2 MANIFOLDS} &= 2 \times 200 = 400 \text{ MAN HOURS} \\ &= 2 \times \$3500 = \$7000 \text{ Computer Costs} \end{aligned}$$

NAME JOE TUREK (WITH SCO--1) ALL 560'S EST'S
DATE 07-2-26
ASSEMBLY NUMBER
ASSEMBLY NAME CANNON GFE TO BEUSE/ARDEC

TASKS REQ'D TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT
YOUR ANALYSIS/CALC'S
DETAILING
EST. NO. OF DETAIL DWGS :
PARTS LIST TASKS
CALC/ASSIGNING OF ALL PART WTS
ASSIGNING OF ALL PART NO'S
MFG/MAT'L REVIEW (SHORT)
CHECKING (HRS OF SOMEONE ELSE'S TIME)
REVISIONS (SHORT) 10
OTHER

TOTAL HOURS TO FINISH TASK 10
EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:
TASK ANALYST'S HR
ESTIMATE

NAME JOE TUREK (WITH TIM)
DATE 07-2-26
ASSEMBLY NUMBER
ASSEMBLY NAME AUTOPRIMER N.5111

TASKS REQ'D TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT
YOUR ANALYSIS/CALC'S
DETAILING
EST. NO. OF DETAIL DWGS :
PARTS LIST TASKS
CALC/ASSIGNING OF ALL PART WTS
ASSIGNING OF ALL PART NO'S
MFG/MAT'L REVIEW (SHORT)
CHECKING (HRS OF SOMEONE ELSE'S TIME)
REVISIONS (SHORT) 5
OTHER

TOTAL HOURS TO FINISH TASK 5
EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:
TASK ANALYST'S HR
ESTIMATE

NAME JOE TUREK

DATE 07-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME CANNON ASSY (MACHINING OF COLLARS & PISTONS)

+ KEYS

TASKS REQ'D TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/MACHINING OF ALL PARTS

FINISHING OF ALL PARTS

ASSEMBLING PARTS

CHECKING WORK OF SOMEONE ELSE'S TIME

REWORKING PARTS

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (MM/YY)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME JOE TUREK

DATE 07-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME DESIGN OF B&B TRAVEL SUPPORT

TASKS REQ'D TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/MACHINING OF ALL PARTS

FINISHING OF ALL PARTS

ASSEMBLING PARTS

CHECKING WORK OF SOMEONE ELSE'S TIME

REWORKING PARTS

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (MM/YY)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME JOE TUPEK

DATE 87-2-24

ASSEMBLY NUMBER 5710-175

ASSEMBLY NAME A310E KICKER TEL SPEC

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART MTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR
ESTIMATE

NAME JOE TUPEK (WITH MARK)

DATE 87-2-26

ASSEMBLY NUMBER 5710-240

ASSEMBLY NAME CANNON ASJ INTO CRADLE DWG

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART MTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR
ESTIMATE

60

61

NAME JOE TURK (WITH BART, DAVEY (EXP. SGT.))
 DATE 07-2-76
 ASSEMBLY NUMBER
 ASSEMBLY NAME HYD. SYS. DETAILING

TASKS REQ'D TO FINISH TASK
 AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DMGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

DESIGNING OF ALL PART NOS

REV. AND REVIEW (HOF)

CHECKING WORKS OF SOMEONE ELSE'S TIME

REVIEWING (HOF)

OTHER

TOTAL HOURS TO FINISH TASK 60

EST. COMPLETION DATE (W/MO) 3-13-87

ESTIMATE OF ADD'L ANALYSIS NEEDS:
 TASK ANALYST'S HR ESTIMATE

NAME JOHN GREEN
 DATE 07-2-76
 ASSEMBLY NUMBER
 ASSEMBLY NAME FINAL EQUILIBRATION/ELEVATION ANALYSIS

TASKS REQ'D TO FINISH TASK
 AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DMGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

DESIGNING OF ALL PART NOS

REV. AND REVIEW (HOF)

CHECKING WORKS OF SOMEONE ELSE'S TIME

REVIEWING (HOF)

OTHER

TOTAL HOURS TO FINISH TASK 80

EST. COMPLETION DATE (W/MO) 3-13-87

ESTIMATE OF ADD'L ANALYSIS NEEDS:
 TASK ANALYST'S HR ESTIMATE

NAME JOHN GREEN (WITH SCOTT)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME PREPARE SPECIFICALLY FOR INCLUSION IN DAR

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DAYS

PARTS LIST TESTS

CALC/ASSEMBLING OF ALL PART NOS

ASSEMBLING OF ALL PART NOS

REVIEW/REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/MO) 3-15-87

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HP ESTIMATE

NAME JOHN GREEN (WITH SCOTT)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME PREPARE TEXT FOR DAR

TASKS REQ'D TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DAYS

PARTS LIST TESTS

CALC/ASSEMBLING OF ALL PART NOS

ASSEMBLING OF ALL PART NOS

REVIEW/REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (W/MO) 3-20-87

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HP ESTIMATE

NAME JUDY LOBECK (WITH DAVE WARWICK)
 DATE 87-2-26
 ASSEMBLY NUMBER
 ASSEMBLY NAME DETAIL FET SUCE & MID SUCE MANUFACTURE

TASKS REQ'D TO FINISH TASK
 FINISH ASSEMBLY AS OF MON. MARCH 2 4:50 P M
 LAYOUT 180 + 161
 YOUR ANALYSIS/CALC'S (MAY 15%)

DETAILING

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MES/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 361

EST. COMPLETION DATE (MM/YY)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

FINISH MACHINE BY JULY 1

8-9 WKS OF WORK

66

KENT
 NAME WILLIAMS
 DATE 2/26
 ASSEMBLY NUMBER 5710-575
 ASSEMBLY NAME SIBER SHIFT ASSY

TASKS REQ'D TO FINISH TASK
 FINISH ASSEMBLY AS OF MON. MARCH 2
 LAYOUT 5
 YOUR ANALYSIS/CALC'S 2
 DETAILING 45

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MES/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 24.5

EST. COMPLETION DATE (MM/YY)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

+ Next Sheet

67

NAME KENT WILLIAMS

DATE 87-2-26

ASSEMBLY NUMBER 5710-575

ASSEMBLY NAME SPEEDSHIFT ASSY DWG

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME Kent Williams (GINT-MARK)

DATE 87-2-26

ASSEMBLY NUMBER 5710-340

ASSEMBLY NAME CRADLE ASSY TO GIRDEL DWG

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME Kent Williams

DATE 87-2-26

ASSEMBLY NUMBER 570-075

ASSEMBLY NAME TOW POSITION, SEE-THRU

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MF3/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME Kent Williams

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME FINALIZE ALL BEARING JOINT DESIGNS

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MF3/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

70

71

6 Times
500's

~~ANALYST: S. MR~~
~~ESTIMATE~~

37

NAME KENT WILLIAMS

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME: CALC. CG. OF CTHD

TASKS REQ'D TO
FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/RECORDS

DETAILING

EST. NO. OF DETAIL DUES TO

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

APPROX. REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

RELATIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS

TASK

ANALYST'S HR
ESTIMATE

NAME LAUREN REZAC (WITH DIANE, SUSLON)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME TRAIL

TASKS REQ'D TO
FINISH ASSEMBLY

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DUES TO

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

APPROX. REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

RELATIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS

TASK

ANALYST'S HR
ESTIMATE

For 100% level of
CONFIDENCE, with to
JULY TIME FRAME

NAME MARK

RUMPSA

DATE

2/27/87

ASSEMBLY NUMBER

ASSEMBLY NAME

FIRE CONTROL ASSY

TASKS REQ'D TO

FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK

AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DEVELOPING ASSY Dwg CREATION

20

EST. NO. OF DETAIL DWGS

1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

MF3/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

20

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME MARK RUMPSA (WITH DIANE, LAUREN, SUELEEN)

DATE 87-2-26

ASSEMBLY NUMBER 5710-600

ASSEMBLY NAME TRAIL SUBASSEMBLY DWG

TASKS REQ'D TO

FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK

AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DEVELOPING ASSY Dwg CREATION

30

EST. NO. OF DETAIL DWGS

1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

MF3/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

30

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME MARK RUMPSA (WITH PARTY-KENT)

DATE 87-2-26

ASSEMBLY NUMBER 5710-475

ASSEMBLY NAME LOAD TRAY C/WAY ASSY DWGS

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING ASSY DWGS 30

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

REF/INT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 30

EST. COMPLETION DATE (Wk./MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME MARK RUMPSA (WITH PARTY-KENT)

DATE 87-2-26

ASSEMBLY NUMBER 5710-475

ASSEMBLY NAME GIMBAL-PLATFORM SPACE SUBASSY DWGS

TASKS REQ'D TO FINISH TASK
FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING ASSY DWGS 25

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

REF/INT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 25

EST. COMPLETION DATE (Wk./MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME MARK RUMPSA

DATE 07-2-26

ASSEMBLY NUMBER 5710-001

ASSEMBLY NAME INSPECT AT OVERVIEW

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYST/CALL'S

DETAILING 40

EST. NO. OF DETAIL DWGS 1

PARTS-LIST TASK'S

CALC/ASSIGNING-OF-ALL-PART WTS

ASSIGNING OF ALL-PART NO'S

NEGATIVE REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT) FOR PARTS LIST

OTHER?

TOTAL HOURS TO FINISH TASK 40

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS-NEEDS:

TASK

ANALYST'S HR ESTIMATE

NAME MARK RUMPSA

DATE 07-2-26

ASSEMBLY NAME

QUALITATIVE INTEGRATION (ASSYS NOT DIRECTLY RESPONSIBLE FOR) + UPDATE TOP

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYST/CALL'S

DETAILING

EST. NO. OF DETAIL DWGS 1

CALC/ASSIGNING-OF-ALL-PART WTS

ASSIGNING OF ALL-PART NO'S

NEGATIVE REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT) FOR PARTS LIST

OTHER?

TOTAL HOURS TO FINISH TASK 220

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS-NEEDS:

TASK

ANALYST'S HR ESTIMATE

INTER-TEAM S MEET / QUALITATIVE 120 HRS

UPDATE TOP 100

80

81

NAME MARK RUMPSA (WIFE JEFF)

DATE 87-2-26

ASSEMBLY NUMBER 5710 - 460

ASSEMBLY NAME HYDRAULIC FUNCT DETAIL

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING 10

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

MBG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 10

EST. COMPLETION DATE (MM/MD)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME MARK RUMPSA (WIFE JEFF)

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME GIMBAL, DETAIL WELD & MACH

TASKS REQ'D TO FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING 60

EST. NO. OF DETAIL DWGS 8

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

MBG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME) 8

REVISIONS (SHORT) 5

OTHER

TOTAL HOURS TO FINISH TASK 73

EST. COMPLETION DATE (MM/MD)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME NAME RUMPSA

DATE 2/27/87

ASSEMBLY NUMBER

ASSEMBLY NAME BTRCH AREA OF CANNON ASSY

TASKS REQ'D TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING 1357 MWL PLOT 35

EST. NO. OF DETAIL DWGS 1

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REFS/MAT'L FEED/EN (SHORT)

CHECKING WPS OF SOMEONE ELSE'S TIME

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 25

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME PATTY YELICH

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME CANNON

TASKS REQ'D TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING (WPS OF DETAILING) 150

EST. NO. OF DETAIL DWGS 136

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REFS/MAT'L FEED/EN (SHORT)

CHECKING WPS OF SOMEONE ELSE'S TIME

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 344

EST. COMPLETION DATE (WK/MO) 4/3

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

89

85

5

NAME Rom Larson

DATE 2/25

ASSEMBLY NUMBER 570-425

ASSEMBLY NAME Load Carry Way

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

15

YOUR ANALYSIS/CALC S

2

DETAILING

390

EST. NO. OF DETAIL DWS

65

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

1

ASSIGNING OF ALL PART NOS

2

MFG/MAT L REVIEW (SHORT)

40

CHECKING (HRS OF SOMEONE ELSE'S TIME)

130

REVISIONS (SHORT)

65

OTHER

TOTAL HOURS TO FINISH TASK

660

EST. COMPLETION DATE (MM/YY)

3/3

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR

ESTIMATE

ASSUMES
NO RE-WORK
DUE TO 30
HOURS ON GEAR.

89

NAME PATTY VELICH

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME CONTRIBUTION TO FINISH STRESS ANALYSIS REPORT

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

20

YOUR ANALYSIS/CALC S

20

DETAILING

20

EST. NO. OF DETAIL DWS

20

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

20

ASSIGNING OF ALL PART NOS

20

MFG/MAT L REVIEW (SHORT)

20

CHECKING (HRS OF SOMEONE ELSE'S TIME)

20

REVISIONS (SHORT)

20

OTHER

20

TOTAL HOURS TO FINISH TASK

20

EST. COMPLETION DATE (MM/YY)

2/4

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR

ESTIMATE

88

NAME ROY LARSON (WORKSHEET)

DATE 87-2-26

ASSEMBLY NUMBER 5710-400

ASSEMBLY NAME FIVE CONT-RL

TASKS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT 120

YOUR ANALYSIS/CALC S 5

DETAILING (25%) 150

EST. NO. OF DETAIL DWGS 25

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS 15

REASSIGNING OF ALL PART NO S 3

REVIEW (SHORT) 25

CHECKING (HRS OF SOMEONE ELSE'S TIME) 50

REVISIONS (SHORT) (25%) 25

OTHER

TOTAL HOURS TO FINISH TASK 395

EST. COMPLETION DATE (W/MO) 2

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME Coll Backo

DATE 2/25

ASSEMBLY NUMBER 5710-100

ASSEMBLY NAME

TASKS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

REASSIGNING OF ALL PART NO S

REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 4

EST. COMPLETION DATE (W/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

NAME Dacko
DATE 2/25
ASSEMBLY NUMBER 5710-400
ASSEMBLY NAME FC + OPTICS

TASK'S REQ'D TO
FINISH ASSEMBLY
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR
ESTIMATE

NAME Dacko
DATE 2/25
ASSEMBLY NUMBER 5710-200
ASSEMBLY NAME BI I + CONTAINER

TASK'S REQ'D TO
FINISH ASSEMBLY
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NOS

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR
ESTIMATE

ID BJI's
SIZE CONTAINER
(CONFIGURE CONTAINER
+ MOUNTING SURFACE
DETAILS)

NAME Dacko

DATE 2/25

ASSEMBLY NUMBER 5710-500

ASSEMBLY NAME NAME PLATES A41 LOCATION

TASKS REQ'D TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

NAME

DATE

ASSEMBLY NUMBER

ASSEMBLY NAME

TASKS REQ'D TO FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR ESTIMATE

94

95

NAME *Dacko*

DATE *2/25*

ASSEMBLY NUMBER *5710-825*

ASSEMBLY NAME *OLC PROC'S*

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME

DATE

ASSEMBLY NUMBER

ASSEMBLY NAME

PREPARE DYNAMIC ANALYSIS REPORT

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER?

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

NAME Dacko RMP: 8
 DATE 2/25 FSM: 8
 ASSEMBLY NUMBER TB.0.
 ASSEMBLY NAME LIFTING EYEJ + TIE DOWNS

TASKS REQ'D TO FINISH TASK
 FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT _____
 YOUR ANALYSIS/CALC'S _____
 DETAILING _____
 EST. NO. OF DETAIL DWGS: _____
 PARTS LIST TASKS _____
 CALC/ASSIGNING OF ALL PART WTS _____
 ASSIGNING OF ALL PART NO'S _____
 MSG/MAT'L REVIEW (SHORT) _____
 CHECKING (HRS OF SOMEONE ELSE'S TIME) _____
 REVISIONS (SHORT) _____
 OTHER _____

TOTAL HOURS TO FINISH TASK _____
 EST. COMPLETION DATE (WK/MO) _____

ESTIMATE OF ADD'L ANALYSIS NEEDS: ANALYST'S HR
 TASK ESTIMATE

NAME SCOTT DACKO
 DATE 87-2-26
 ASSEMBLY NUMBER _____
 ASSEMBLY NAME MTG HANDPUMPS & JOYSTICKS

TASKS REQ'D TO FINISH TASK
 FINISH ASSEMBLY AS OF MON. MARCH 2

LAYOUT _____
 YOUR ANALYSIS/CALC'S _____
 DETAILING _____
 EST. NO. OF DETAIL DWGS: _____
 PARTS LIST TASKS _____
 CALC/ASSIGNING OF ALL PART WTS _____
 ASSIGNING OF ALL PART NO'S _____
 MSG/MAT'L REVIEW (SHORT) _____
 CHECKING (HRS OF SOMEONE ELSE'S TIME) _____
 REVISIONS (SHORT) _____
 OTHER _____

TOTAL HOURS TO FINISH TASK 14
 EST. COMPLETION DATE (WK/MO) _____

ESTIMATE OF ADD'L ANALYSIS NEEDS: ANALYST'S HR
 TASK ESTIMATE

NAME SCOTT DACKO

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME CURRENT SVR. STABILITY FROM BATTERY & LOAD FOR IN GRADING
& AGAINST CURS TO ARDEC

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

REVIEW (SHORT)

CHECKING (USE OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

40

EST. COMPLETION DATE (WK./MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR
ESTIMATE

TASK

NAME SCOTT DACKO

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME CAPITAL GSE TO BENE-ARDEC

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

REVIEW (SHORT)

CHECKING (USE OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

5

EST. COMPLETION DATE (WK./MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR
ESTIMATE

TASK

100

101

NAME

Scott Backo

DATE

ASSEMBLY NUMBER

ASSEMBLY NAME *FINA RECASTING*

TASKS REQ'D TO

FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK

AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

REASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK:

ANALYST'S HR

ESTIMATE

NAME SEAN MAREK

DATE 07-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME PREPARE APPENDIX FOR PAR

TASKS REQ'D TO

FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK

AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

REASSIGNING OF ALL PART NO'S

MFG/MAT'L REVIEW (SHORT)

CHECKING (HRS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK:

ANALYST'S HR

ESTIMATE

16 hours as of 7:30 am 26-Feb

4.8

(Only 1 revision is with up necessary)

6

NAME SEAN MAREK

DATE 87-2-26

ASSEMBLY NUMBER

ASSIGN NAME PREPARE WETUP OF ANALYSIS FOR VAR

TASKS REQUIRED TO
FINISH ASSEMBLY

4 HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

*(hours needed by wirewings to finish
write up all necessary)*

YOUR ANALYSIS PARTS

DETAILING

EST. NO. OF DETAIL DWS

PARTS LIST ITEMS

CONSTRUCTION OF PARTS LIST

RECORDING OF PARTS LIST

REVIEW OF PARTS LIST

CHECKING PARTS OF SOMEONE ELSE'S TIME

REVIEWING PARTS

ST-SET

TOTAL HOURS TO FINISH TASK

4

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR
ESTIMATE

NAME SEAN MAREK

DATE 87-2-26

ASSEMBLY NUMBER

ASSIGN NAME: DETERMINE CRITICAL PARAMETERS OF LAY CONTROL

TASKS REQUIRED TO
FINISH ASSEMBLY

0 HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

*Task is completed plus configuration
by own changes.*

YOUR ANALYSIS PARTS

DETAILING

EST. NO. OF DETAIL DWS

PARTS LIST ITEMS

CONSTRUCTION OF PARTS LIST

RECORDING OF PARTS LIST

REVIEW OF PARTS LIST

CHECKING PARTS OF SOMEONE ELSE'S TIME

REVIEWING PARTS

ST-SET

TOTAL HOURS TO FINISH TASK

0

EST. COMPLETION DATE (WK/MO)

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR
ESTIMATE

NAME Tom Rudolph
 DATE 87-02-26
 ASSEMBLY NUMBER
 ASSEMBLY NAME

TASKS REQ'D TO
 FINISH ASSEMBLY
 LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING IN HOUSE COMPOSITE PARTS 120.0

EST. NO. OF DETAIL DWGS 1.5
 DETERMINING MADE/BUY Comp Parts 16.0
 PARTS LIST TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REF/NO 1 REVIEW (SHORT) - NEWS/REV PARTS ?

CHECKING (HPS OF SOMEONE ELSE'S TIME) CONVINCING PART NO'S TEST

REVISIONS (SHORT) DESIGN SUPPORT ANALYSIS 80 (REVISION) 80 (CHECKS - LAMINATE STRESS)

OTHER FATIGUE VIBRATION PLAN 36.0

Test Plan Section 4.0

TOTAL HOURS TO FINISH TASK 356

EST. COMPLETION DATE (WK/MO) 1/5 +

14th of APRIL

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

106

NAME 70M VOLKMAN
 DATE 87-2-26
 ASSEMBLY NUMBER

ASSEMBLY NAME: ANALYSIS OF RAINING SYSTEM

TASKS REQ'D TO
 FINISH ASSEMBLY
 LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWGS

DATE FOR TASKS

CALC/ASSIGNING OF ALL PART WTS

ASSIGNING OF ALL PART NO'S

REF/NO 1 REVIEW (SHORT)

CHECKING (HPS OF SOMEONE ELSE'S TIME)

REVISIONS (SHORT)

OTHER

TOTAL HOURS TO FINISH TASK 60

EST. COMPLETION DATE (WK/MO) 87-3-28

ESTIMATE OF ADD'L ANALYSIS NEEDS:

TASK ANALYST'S HR ESTIMATE

ALL: ASSUMES GO HAS / wa

107

NAME VOLKMAN/J

DATE 87-2-26

ASSEMBLY NUMBER

ASSEMBLY NAME CHECK FORTING LOGIC, STRUCTURALLY ANALYZE,
AND MINIMIZE WEIGHT OF MID-MANIFOLD & FRT MANIFOLD.

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWS

BASIC PART TASKS

CALC ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

REWORK & REENTER PART NOS

CHECKING USE OF SOMEONE ELSE'S TIME

REWORKING PARTS

OTHER

TOTAL HOURS TO FINISH TASK

150

EST. COMPLETION DATE (WK/MO)

87-3-27

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR

ESTIMATE

TASK

NAME VOLKMAN/J

DATE 87-2-26

ASSEMBLY NUMBER

TEXT 4

ASSEMBLY NAME PREPARE APPENDIX/ SECTIONS FOR DAR & ~~SECTION~~ REPORT.

TASKS REQ'D TO
FINISH ASSEMBLY

HOURS REQUIRED TO FINISH TASK
AS OF MON. MARCH 2

LAYOUT

YOUR ANALYSIS/CALC'S

DETAILING

EST. NO. OF DETAIL DWS

BASIC PART TASKS

CALC ASSIGNING OF ALL PART NOS

ASSIGNING OF ALL PART NOS

REWORK & REENTER PART NOS

CHECKING USE OF SOMEONE ELSE'S TIME

REWORKING PARTS

OTHER

TOTAL HOURS TO FINISH TASK

30

EST. COMPLETION DATE (WK/MO)

87-4-11

ESTIMATE OF ADD'L ANALYSIS NEEDS:

ANALYST'S HR

ESTIMATE

TASK

NAME VOLKMANIJ

DATE 87-2-26

AGENCY NUMBER

4 APPENDIX

ASSEMBLY NAME: PREPARE TEXT FOR ~~9888~~ STRESS ANALYSIS REPORT

TASKS REQUIRED TO FINISH TASK AS OF MON. MARCH 2

LAYOUT

YOUR ANALYST/CHECK'S

DEPARTING

EST. NO. OF DETAIL DINGS

PAPER TEST TASKS

ORGANIZING OF ALL PARTS

RESEARCHING OF PART NO'S

RESEARCHING (PARTS)

CHANGING LINES OF SOMEONE ELSE'S TIME

RESEARCHING (PARTS)

OTHER

TOTAL HOURS TO FINISH TASK 60

EST. COMPLETION DATE (WK/MO) 87-4-11

ESTIMATE OF ASS'L ANALYSIS NEEDS:

TASK

ANALYST'S HR
ESTIMATE

Review circuit system analysis for
time cycle, temperature sensitivity,
circuit & initial wiring 30

Supply voltage, component position &
structural overview, since initial
drawing illustrate 30

Prepare text and graphics for SAR 30

Analysis of part and material life
for testing logic, material
simulation check for stress
sensitive areas and basic structural
requirements data, preliminary
determination of weight minimize
possibilities, investigate of time &
cost for most effective stress analysis
& weight reduction program
initially find about analysis of
plastic or such ability & testing 120

Actual analysis and testing for stress
and weight minimize ?

Prepare text and graphics for SAR
not including actual analysis and
testing reports 60

Review with analysis and test personnel
during analysis, analysis, & test plan 30

END

10-87

DTIC